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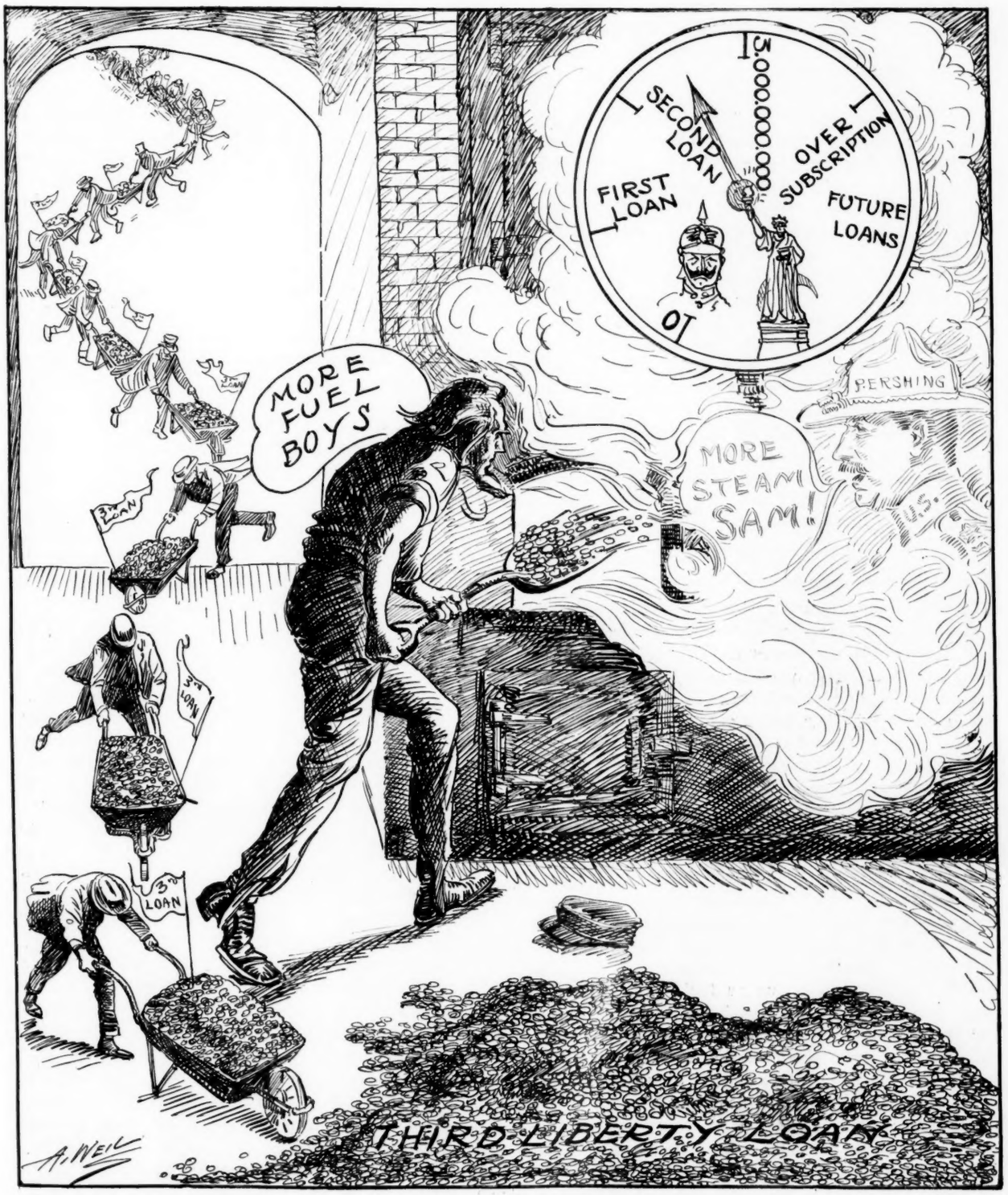


Combustion of North Dakota Lignites With Suggestions for Design of Furnaces

By HENRY KREISINGER
Engineer, United States Bureau of Mines

Convinced that those adjacent to the great lignite fields should learn how best to use this fuel and not draw upon the coal from distant mines, "Power" some time ago requested Dr. Manning, of the Bureau of Mines, to permit Mr. Kreisinger to write for "Power" an article in which he would present the results of his investigations in the commercial use of lignites in which the West and Northwest abounds. The article is therefore published by permission of Dr. Manning, Director of the United States Bureau of Mines, and is in part from a report to be submitted to the Director. Mr. Kreisinger points out that combustion is limited to about the first three inches of the fuel bed and that the CO_2 is rapidly and completely reduced to CO at about four inches from the grate, necessitating the introduction of oxygen (air) above and against the fuel bed. Because of the heat-absorbing effect of CO_2 reducing to CO and because of the high moisture content, the flame should sweep forward over the fuel bed. The horizontal grate is unsuited to lignite, a step-grate with large air openings being best adapted. The article should help those who will burn lignite because of the Fuel Administration's zone system for the distribution of coal.

THE natural lignite of North Dakota is of a brown color and has a distinct woody structure. Approximate analysis shows it to contain 40 per cent. moisture, 25 per cent. volatile matter, 28 per cent. fixed carbon and 7 per cent. ash. The heating value of natural lignite is very low, being only about 6300 B.t.u. per pound. When exposed to weather, the moisture evaporates rapidly and the lignite crumbles into small flat pieces, or flakes. Similar crumbling also takes place, to a large extent, in the fire and is one of the chief objections to burning lignite. The high moisture content and the crumbling when exposed to weather are serious drawbacks to transportation of the lignite over long distances, thus limiting the use of this fuel to comparatively small districts around the lignite mines.

To avoid these objections attempts are being made to carbonize the lignite in coke ovens or in gas retorts and use the carbonized residue as fuel. The residue has much lower moisture and much higher heat value, and for this reason there seem to be possibilities that it could find use over wider territories. The residue analyzes about 14 per cent. moisture, 9 per cent. volatile matter, 66 per cent. fixed carbon and 11 per cent. ash. Its heating value is 10,400 B.t.u. per pound. It consist mostly of small pieces, all of which pass through ½-in. screen and about 40 per cent. through ⅛-in. screen. It is dull gray, almost black in color, and under a low-power microscope appears to be of homogeneous structure, somewhat like some of the hard bituminous coals. Its specific weight is about 0.8 that of anthracite of similar size.

Combustion Qualities of Lignite and Its Carbonized Residue

In the ordinary furnace with horizontal grate the lignite of North Dakota is very difficult to ignite. The surface of the fuel bed is rather dark and uncheerful, with flames appearing only in spots. The flames are of bluish yellow color and clean, containing little soot. The crumbling of the lignite makes a rather dense fuel bed, offering high resistance to the flow of air. Some of the small pieces sift through the grate and continue to burn in the ashpit, especially if the fire is disturbed. With careless handling of the fire so much burning lignite may be sifted through the grate that the ashpit may have more fire than the furnace. In the fuel bed the processes of combustion are largely limited to the first three inches from the grate. This is probably partly due to the compactness of the fuel bed and partly to the high activity of the carbon in the lignite. The compactness of the fuel bed breaks the current of air passing up through it into many small streams, so that the oxygen and the products of combustion come in close contact with the hot carbon. The carbon may be in such form that it combines rapidly with the oxygen and also with CO_2, which acts as an oxidizing agent. The carbon combines with the oxygen passing up through the layer next to the grate and forms CO_2. The CO_2 itself is rapidly and almost completely reduced to CO three to four inches from the grate so that at the surface of the fuel bed there is practically no oxygen and little, frequently less than 1 per cent., of CO_2. The reduction of CO_2 to CO is a heat-absorbing process, consequently a large part of the heat generated in the layer next to the grate is absorbed in the upper layers of the fuel bed by the reduction. This heat absorption by the reduction process is partly a cause of the darkness of the surface of the fuel bed. The high moisture content of the lignite causes this fuel to absorb large quantities of heat and is a further cause of the darkness at the top of the fuel bed. The processes of combustion in the fuel bed are shown graphically in Fig. 1, which shows the results of some combustion experiments made at the Bureau of Mines.

The rapid oxidation limits the high temperature to a thin zone near the grate, where most of the ashes accumulate, and because of the heat tend to fuse into clinker.

The gases rising from the fuel bed consist mostly of CO, hydrogen and light hydrocarbons, all of which are easily burned. There seem to be no, or little, hydrocarbons which are likely to decompose and produce smoke; consequently the lignite, compared with bituminous coals, can be considered as a smokeless fuel. Complete combustion is further aided by the fact that the distillation of volatile matter is nearly uniform through-

out a firing cycle, provided the firings are not too far apart in point of time; the distillation being uniform, it is easy to supply the right amount of air to burn lignite completely without large excess of air. When burning lignite, there are no such high peaks of combustible gases immediately after firing, demanding large air supply, as is the case with bituminous coals; in fact, the demand for air is about as uniform as it is in hand-firing anthracite coal. This feature is shown in Fig. 2, which gives the percentages of CO_2 in the furnace gases taken at 15- to 20-sec. intervals during several firings when burning lignite, anthracite, Pocahontas and Pittsburgh coals, the length of the firing cycle being the same in all cases.

The carbonized residue, being of small size, lies compactly on the grate and offers high resistance to the flow of air through the fuel bed; high draft is required even with a 4-in. fuel bed and moderate rates of combustion. This high resistance to the passage of air is probably the greatest drawback to burning the carbonized residue on a horizontal grate. The high draft is likely to blow holes through the fuel bed and make an uneven fire.

The draft required for given rates of combustion of natural lignite and the carbonized residue is shown graphically in Fig. 3. As indicated in the figure, it is practically impossible to obtain rates of combustion of 20 to 30 lb. with a 6-in. fuel bed of the residue with a chimney draft.

Behavior of the Fuel Bed

The activity of the carbon to combine with oxygen and CO_2 is even greater than that of the carbon in the natural lignite. The oxygen passing up through the grate is all consumed in burning the carbon to CO_2, and the CO_2 reduced to CO in the first two or three inches above the grate; the upper layers in the fuel bed remain practically inactive. The reducing process keeps the gases comparatively cold and the top of the fuel bed dark, unless the rates of combustion are increased beyond 30 lb. On ordinary grates such high rates of combustion would require high draft. When the rate of combustion of about 40 lb. of fuel per square foot of grate per hour is approached, there is started a strong agitation in the fuel bed; the particles of fuel are moving so that the whole surface of the fuel bed appears like a boiling liquid. When this stage is reached, further increase in the rate of combustion is not accompanied by a proportional increase in the draft required to produce this rate of combustion. This is shown in Fig. 3, particularly by the curve for carbonized residue for a 6-in. fuel bed.

The high temperature resulting from the intensified combustion near the grate tends to melt the ash into clinker. The clinker is dense and impervious to air, and it is doubtful that rates of combustion between 20 and 30 lb. could be maintained more than two or three hours before it would be necessary to remove the clinker. The clinkering tendency is aggravated by the fact that on account of the small size of the fuel, a grate with small air spaces must be used, the air spaces not being sufficiently large to insure continual riddance of ash. The main cause of the clinkering is the low fusing temperature of the ash, which is only about 2000 deg. F.

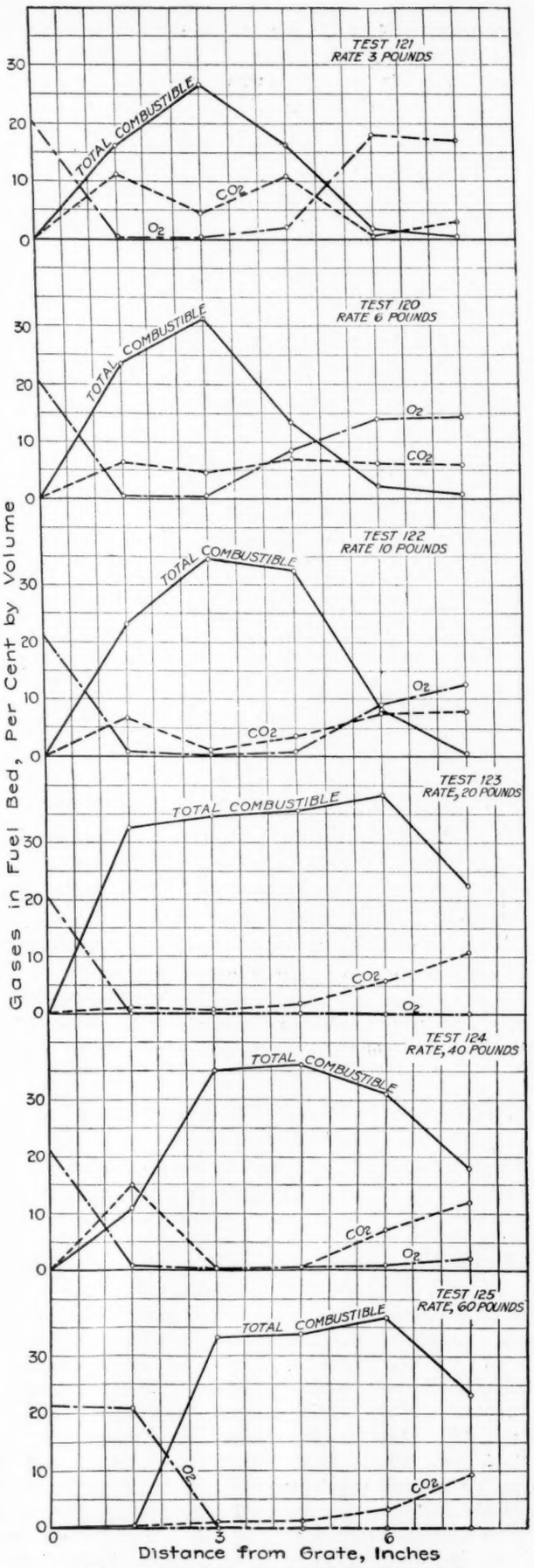


FIG. 1. RESULTS OF COMBUSTION TESTS

The gases rising from the fuel bed contain a large percentage of combustible gas, mostly CO, with no oxygen and practically no CO_2. Judging by the rapidity of the reactions in the fuel bed, it would seem that the natural lignite, as well as the carbonized residue, would make a

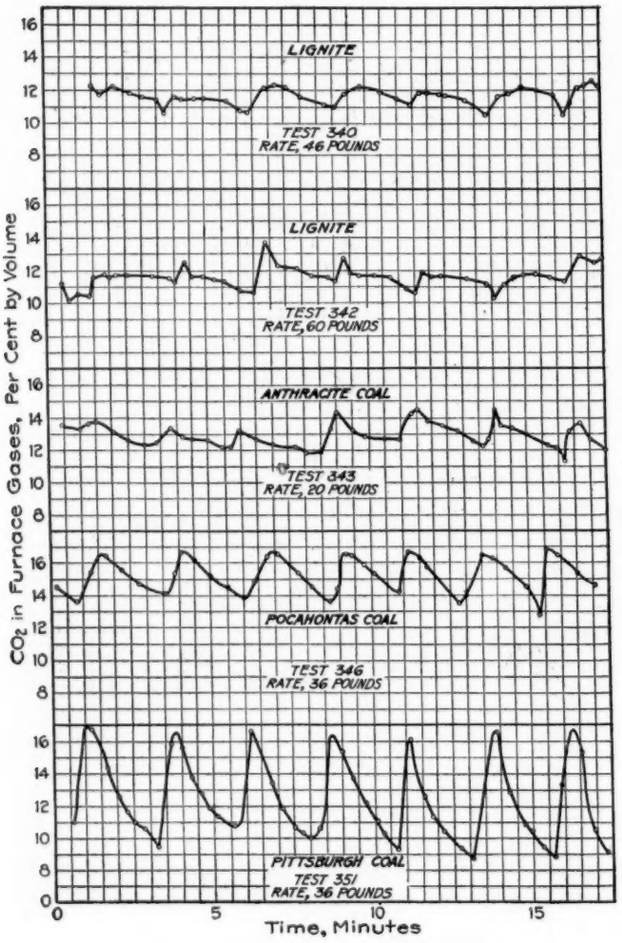


FIG. 2. CO_2 WITH VARIOUS FUELS

good fuel for gas producers, the tendency to clinker, of course, being the only drawback to this fuel for this purpose.

Requirement of a Furnace for Burning Lignite and Its Carbonized Residue

Any furnace that will burn the lignite and its carbonized residue successfully must fulfill the following conditions: It must have a provision for rapid ignition; it must supply enough air with ordinary draft to produce a reasonably high rate of combustion and make a hot fire; it must have a grate of such design that will prevent sifting of combustible into the ashpit and at the same time permit of cleaning the fire without impairing its function. A special furnace was designed and constructed in accordance with these requirements and with particular application to house-heating purposes. The essential features are shown in Fig. 4.

Rapid ignition is obtained by the rear arch, which turns the hot gases and flames back over the fuel bed. Thus, the incoming fresh fuel is heated not only by conduction through the fuel and radiation from the arch, but mainly by convection by coming in contact with the hot gases and flames from the already burning fuel. If a long front arch is used with no rear arch, the flames and hot gases flow away from the incoming coal and the fire has a tendency to be moved from under the arch and extinguished.

To heat lignite having 35 per cent. moisture to ignition temperature takes more than twice as much heat as is required to heat bituminous coal containing 10 per cent. of moisture. It is therefore difficult, if not impossible, to supply enough heat by radiation from the ordinary front arch to ignite the lignite. The rate of heat transmission by radiation depends almost entirely on the temperature. Therefore, to supply more than twice the heat by radiation from the arch would require that the arch be kept at considerably higher temperature when burning lignite than when burning ordinary bituminous coal. But with lignites it is not possible to obtain temperatures nearly as high as with bituminous coals. Therefore, it is plain that another factor in the heat transfer must be brought into action, and that is the heat transmission from the hot gases by convection.

The grate is inclined and has wide horizontal air spaces which can be easily kept open, permitting free flow of air through the grate. Additional air is admitted through the clinker-removing door at the lower end of the grate. As this air passes up between the arch and the fuel, it scrubs against the surface of the fuel bed and a large part of it is used in burning or gasify-

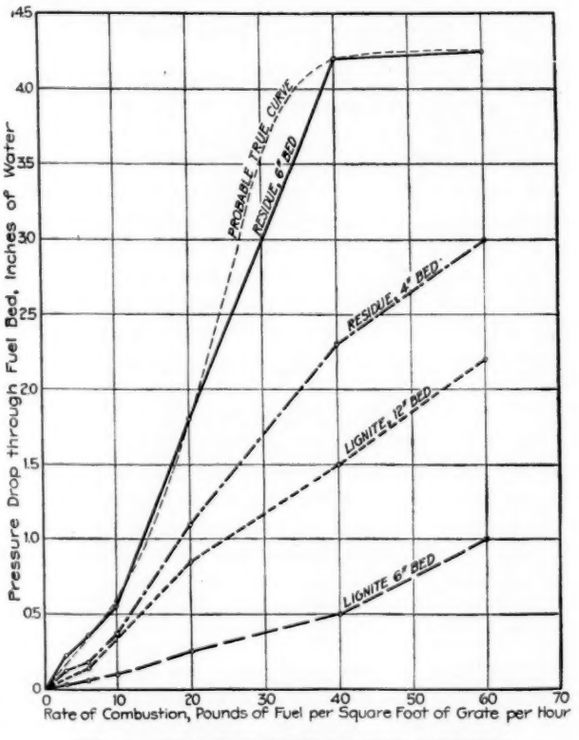

PROBABLE TRUE CURVE
RESIDUE 6" BED
RESIDUE 4" BED
LIGNITE 12" BED
LIGNITE 6" BED
Pressure Drop through Fuel Bed, Inches of Water
Rate of Combustion, Pounds of Fuel per Square Foot of Grate per Hour

FIG. 3. DRAFT REQUIRED FOR LIGNITE

ing solid fuel, thus making it unnecessary to force all the air needed for the gasification of the fuel through the fuel bed.

Experiments showed that the scrubbing action of the additional air caused a rapid and a rather complete oxidation at the surface of the fuel bed, indicated by the bright-red heat, which was practically absent on the

tests made in an ordinary furnace with horizontal grate. Thus, there were two oxidation zones, one next to the grate and one at the surface of the fuel bed, probably with a small reducing zone between them. Because the air which enters through the cleaning door against a low resistance burns or gasifies solid fuel, higher rates of combustion can be obtained with ordinary natural draft.

The air spaces in the grate are horizontal, and the successive steps or grate bars are overlapping in such a way that there is no sifting of the combustible into the ashpit. The inclination of the grate is such that the fuel is fed from the magazine down the grate by gravity. The rate of feeding can be increased by a slight agitation or rocking of the grate bars. The fuel does not cake, and therefore the gravity feed is not interfered with as is the case with most bituminous coals. Most of the ash slides down the step grate with the fuel and finally reaches the horizontal portion of the grate, after most of the combustible has burned off. The horizontal part of the grate has small air openings through which the ash can be shaken into the ashpit. Any clinker that accumulates on this horizontal portion of the grate can be removed through the door provided for this purpose or by dumping the grate, without disturbing the fire on the inclined grate.

The thickness of the fuel bed, and to some extent the

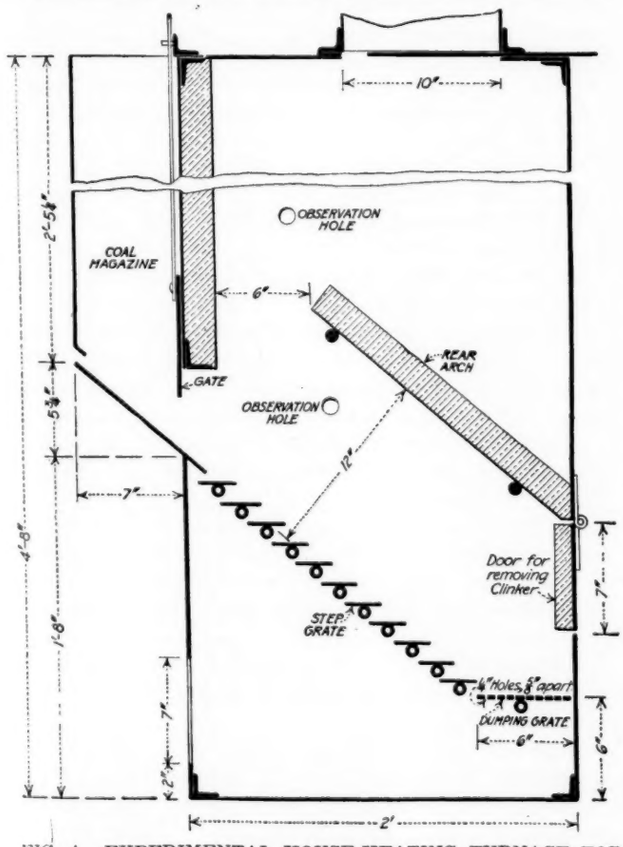


FIG. 4. EXPERIMENTAL HOUSE-HEATING FURNACE FOR LIGNITE

rate of feeding, are controlled by the opening of the gate of the fuel magazine.

A fire was started in this furnace by building a small wood fire on the horizontal portion of the grate and covering the inclined portion with a bed of lignite about four inches thick. As the flames from the wood fire passed over the bed of lignite, they set it afire, so that in less than an hour the lignite over the entire grate was burning. With a draft of 0.1 to 0.15 in. of water, the lignite made a bright, red-hot fire, although the arch never became visibly red-hot. There seemed to

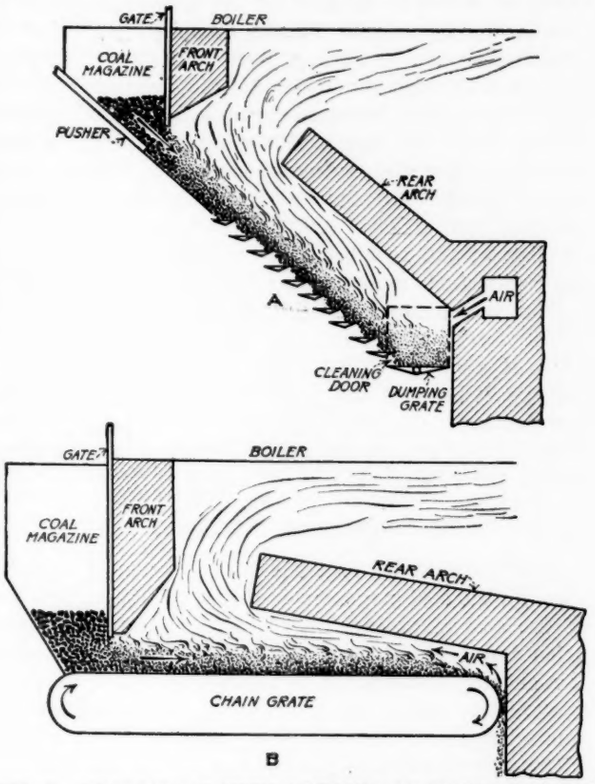


FIG. 5. PROPOSED ROUGH DESIGNS OF FURNACES FOR BURNING LIGNITE UNDER BOILERS

have been considerable combustion at the surface of the fuel bed, due to the air entering through the cleaning door and scrubbing the surface.

When the lignite was broken to pieces not exceeding about two inches, the feeding of the fuel was nearly automatic. With larger pieces the fuel had to be occasionally moved down by moving the grate bars or by poking the large pieces through the magazine gate. The fuel contained a considerable amount of slack, which, however, did not seem to cause any particular trouble. Some clinker was found on and near the horizontal portion of the grate. This clinker was very porous and floated in the free ash without touching the grate, and seemed to have been formed near the surface of the fuel bed. It was removed by hooking it out from the horizontal portion of the grate, and the fine ashes were shaken through.

The carbonized residue, on account of its uniform size, flowed down the inclined grate without any help and made a rather intense fire wholly out of comparison with the sluggish fire that could be obtained on a horizontal grate. In fact, it seems that the carbonized residue, when burned in this special type of furnace, would make an ideal fuel for house-heating purposes.

The principles embodied in the design of the special furnace shown in Fig. 4 can be applied to boiler furnaces with a promise of success. Fig. 5, diagram *A*, suggests the design of an inclined step-grate boiler

furnace. The fuel can be fed down the grate by gravity aided by hand regulation, or it can be pushed out of the magazine mechanically by a pusher plate. The horizontal air spaces between the step-grate bars can be kept open easily by hand poker or by rocking the grate bars. The clinker can be removed through the side cleaning door, or it can be dropped by the dumping grate. The fine ashes accumulate on the dumping grate through which they can be shaken into the ashpit. The air is admitted through the horizontal air spaces between the step-bars of the grate and through the special openings at the end of the grate. Probably two-thirds to three-fourths of the air needed for combustion should be introduced at the end of the grate, so that as the air passes between the fuel bed and the arch it scrubs over the surface of the fuel bed and burns the coal. This air enters the furnace against a very small resistance, therefore a comparatively small draft may bring large quantities of air into the furnace and produce a fairly high rate of combustion. The air entering through the air spaces between the grate bars has to pass through the fuel bed against a comparatively high resistance, and it would require high draft to supply enough air to gasify the solid fuel.

Air Admission to the Fuel Bed

There should be as little air as possible entering through the coal magazine or through the plate in front of the coal magazine, where the fuel is merely being dried and does not burn. The completeness of combustion should be controlled by regulating the air admitted at the lower end of the grate and not by regulating the admission of air through the magazine. The air admitted through the magazine does not help in burning solid coal, but merely assists in burning the gases rising from the lower portion of the fuel bad. The gases rising from a fuel bed of lignite consist mostly of carbon monoxide and hydrogen, which are comparatively easy to burn, so that the flames would not extend too far beyond the top of the arch. The comparatively narrow space between the rear arch and front arch would help in bringing the air and combustible gases together, and cause intimate mixing. There would probably be a considerable amount of the fluffy ash carried with the gases. As soon as the gases pass beyond the contraction between the two arches, they expand and their velocity slows down, causing the ash to be deposited on top of and beyond the rear arch; so that comparatively little ash would be carried into the boiler.

The special openings for introducing air at the end of the grate would not fuse over because they do not come in contact with the hot gases and the slag which the gases contain.

Diagram *B*, of Fig. 5, shows the application of the principles to a chain grate. The diagram shows the grate in horizontal position, but it is believed that better results could be obtained if the top of the grate were inclined about 20 deg. to the horizontal.

The motion of the grate feeds the fuel into the furnace, and the thickness of the fuel bed is controlled by the opening of the gate. The air needed for combustion is introduced through the openings in the grate bars and in the rear of the grate where the ashes are discharged into the ashpit. In this case the air which enters the furnace between the end of the grate and the bridge-wall is used to burn the solid fuel on the grate as it is made to pass between the arch and the fuel bed toward the front of the grate, and therefore helps both in the rate and the completeness of combustion, and is not detrimental to efficiency, as it is with the ordinary chain-grate furnace.

Provisions should be made to stop the admission of air through the coal magazine and through the front part of the grate, where the lignite is being dried. When burning lignites, it is improbable that the furnace temperature will be high enough to injure the arch. With the CO_2 (carbon dioxide) averaging between 13 and 14 per cent., the furnace temperature will not exceed 2200 deg. F., and with the top of the arch exposed to radiate heat to the boiler above it, the arch would probably never get above 2000 deg. F. There are plenty of refractory materials that will hold under such temperatures. When burning carbonized residue, which does not contain such a high percentage of moisture as natural lignite, higher temperatures might be obtained. If these temperatures would be too high for the material in the arch, the latter could be constructed of special tiles suspended from water tubes, which could be made a part of the boiler. Similar construction is used on arches in locomotive furnaces. It should be borne in mind that, since the arches are inclined, only the horizontal component of the weight of the arch acts in pulling the arch down.

These furnaces can probably be used for burning other low-grade fuels that are difficult to ignite.

Something About Pumps

One Saturday afternoon as Willis was on his way home after shutting down for the week's end, he dropped into the engine room of the Stahley Manufacturing Co.'s plant, where an engineer by the name of Williams was in charge. He found Williams working on a pump that was used for returning the water of condensation to the boilers, and a much disgusted person he was at that particular instant.

"How is she coming," asked Willis, as he moved over toward the pump. "You seem to be up to your eye-teeth in trouble this afternoon."

"Trouble's no name for it. Here I am stuck for the day, while the rest of the fellows are off until Monday morning, just because this blamed pump won't work any better than a dog's front legs when it comes to scratching fleas."

"Well, a little thing like a pump should not keep you here very long. What seems to be the matter with it first and last?"

"She won't handle the hot water for a cent. I don't know what's the matter with the dum thing."

During this little conversation Willis had been inspecting the rings of packing that Williams had removed from the water end of the pump and discovered that they were designed for cold water and not at all fitted to pump hot water such as the pump had been handling.

"Where did you get this packing," he asked as Williams straightened up to get the kinks out of his back. "Get it at a rummage sale?"

"No, I got it a few days ago from a fellow who said his packing was just as good as what we had been using and a little cheaper. I fell for his line of talk and have had trouble ever since. What's the matter with the stuff? Do you know?" he asked as he noted the amused look of Willis.

"Surest thing you know," replied Willis. "This packing might be all right for cold water, but for hot water such as you are trying to make this pump handle you

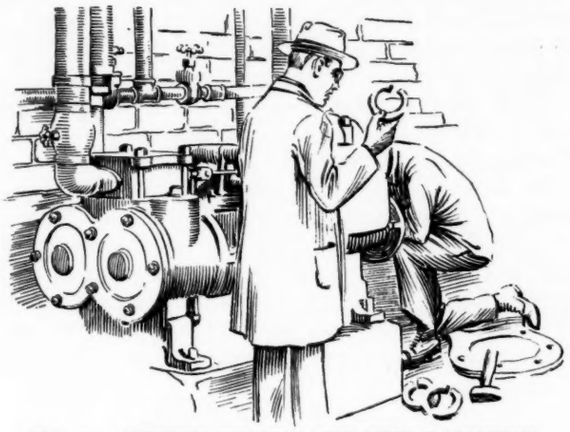


FIG. 1. "WHERE DID YOU GET THIS PACKING?"

might just as well pack it with cheese cloth and be done with it. You put in some packing that is made to work with hot water and I calculate the pump will get down to business in no time. Williams," said Willis, "you can make up your mind to one thing if not another, and that is that when a machine won't do its work there is a good reason, and when it has been working all right for a spell and then suddenly goes wrong, you can gamble that some simple thing has taken place that can be easily remedied. The best thing a fellow can do in such a case is to think a little and see if he hasn't done something that might be responsible for the trouble.

"Now in your case if you had got in a think or two you would have come to the conclusion that something must have happened to the packing, seeing it was the only thing on the pump that was different from the regular state of affairs, and then you would have found, if you had read the label on the box, that the packing was not the kind for the work. Of course you can generally tell by the looks of a packing what kind of water it will handle, although it might be a little difficult in some cases, but this box is plainly marked 'For use with cold water,' as I have observed since I dropped in here. Now I didn't mean to preach you a sermon, but carelessness usually is responsible for most of our troubles and don't you forget it."

"Maybe, maybe," answered Williams, "but that ain't always the case, not by a long shot."

"I never told you about Silas Wetherbee, did I? Well, Silas had a new pump come one day, and after he had got it piped up as spruce as a young feller going courting for the first time, he started it up and the pump was as dry as a one-year old brindle bull. All the prominent engineers around about were called in to set matters right, but although the pump piston would shoot back and forth there wasn't any water coming out of the discharge pipe.

"The pump was of good make; in fact, Silas had another one that had never given any trouble, and he couldn't imagine why the new one wouldn't pick up and go on about its business the same as any decent pump should.

"As it happened, I strolled into the plant when about everyone had condemned the pump to the hottest place they could think of and Silas asked me to try my luck at it. He told me about every thing that had been done to get it started, and I decided there wasn't any use in going over the same road the others had traveled.

"Well, to make a long story short I got Silas to break the suction pipe pretty close up to the pump and then got a pail of water and stuck the short end of the suction pipe in it. Silas started up the pump and that water disappeared quicker than you can say scat. We tried it again and the same thing happened, and I told Silas I calculated that if the pump could get water there wouldn't be any trouble about its throwing a stream out of the discharge pipe to wherever he wanted it to go."

"What was the matter with the pump that it wouldn't take water? Another case of using packing that wasn't fit for the work?"

"Nothing of the sort. The dom idiot had connected the suction pipe to an old one that ran to a pond a little distance away, but which for some reason or other had been abandoned and the suction end left about a foot above the water. Naturally, the water wasn't going to make no hop, skip and a jump that distance into the suction pipe just to please Silas or anyone else.

"Silas said the cigars were on him, and I guess they were for I never saw any of them. However, that little

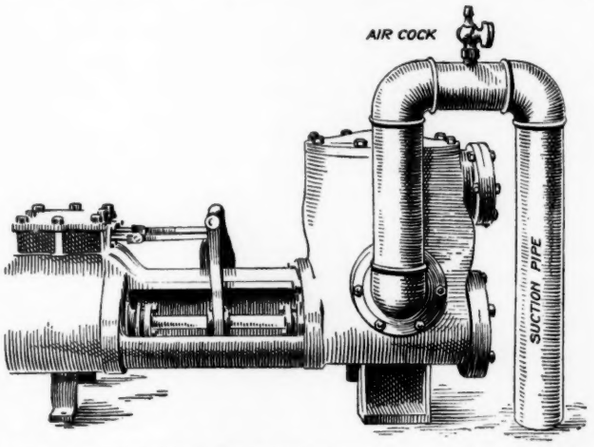


FIG. 2. "WE PUT A PET-COCK IN THE SUCTION PIPE"

incident goes to show that a feller can put up an awful holler when the fault is his own."

"I don't see why anyone would pipe up a pump to an old suction pipe without knowing whether it was in good condition or not."

"You wouldn't think it any more than that a fellow would use cold-water packing to pump hot water," answered Willis with a grin.

"Sometimes a fellow gets a surprise when a pump won't work. I remember some years ago in one plant where I worked a large pump that was used only occasionally was always supposed to be in good condition. The suction pipe was fitted with a foot valve, and it had always worked to perfection. One day I wanted that pump in a hurry, and when steam was turned on there was nothing doing.

"Naturally, I went over the thing and could find nothing out of order. Finally, the foot valve was examined, when we found that the pump valves were dry and the cause of the trouble was discovered to be due to leaves that had lodged against the foot valve and so prevented water from getting up into the pump. Of course the pump had run down, which accounted for the dry valves.

"Foot valves have caused me some trouble, but on the whole I take it that they are better than nothing on the end of the pipe, as they keep fish, eels and other rubbish from getting into the pipe. I always have 'em on my suctions unless the water is coming from a well where there is but little danger of the pipe taking anything large enough to get stuck in the pump valves."

"Yep, I know," answered Williams, "but just the same that foot valve came off the pipe and mighty quick at that. I don't see what there was to prevent the pump from running down without the foot valve just as easily as it did with it on and the clapper stuck open."

"If you will only give me a chance, I'll tell you what was done. You see, we ran the suction pipe up to a point a little above the top of the pump-valve deck and then capped it with an elbow in which a long nipple was screwed. On the other end of the nipple another ell was fitted and the other end of it was fitted to a pipe that connected with the pump. This arrangement gave two legs to the suction pipe, and as the long nipple was fitted with an air valve it was an easy matter to cut the pipe into two sections, so that when the water in the pipe from the supply started to run down, the water in the pipe connected to the pump would remain where it was, and it was there when we wanted to start up. The only thing we had to remember was to open the air-cock when shutting down the pump, just to cut the water into two separate bodies."

"Well, I suppose pumps are necessary about a steam plant, but I wish that someone would get up something that would work without valves and pistons in handling hot-water returns. Then there would be less gloom, for me at least. A pump is a nuisance anyway."

"Why, Williams, you don't mean to say that you don't know of a way to get your returns back into the boiler without a pump, do you? Didn't you ever hear of the return loop? No? Well, I ain't got the time to tell you about it just now, as I have got to get home so as to keep peace in the family; but the next time I get a chance I'll drop in and give you a few pointers on the loop that may come in handy some time or other. Now I guess I'll meander along and see what the old lady's got for dinner."

Whitewash and Fire-Retarding Mixture

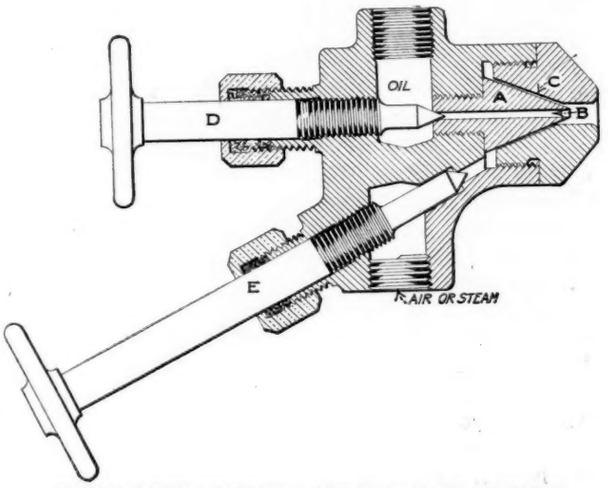
Following is the formula for what is known as the United States Government whitewash mixture, which also acts as a fire-retarding coating over interior wooden surfaces: Slake ½ bushel of quicklime with boiling water, keeping it covered during process; strain and add 1 peck of salt dissolved in warm water; put 3 lb. ground rice in water and boil to a thin paste; ½ lb. of powdered Spanish whiting; 1 lb. of clean glue dissolved in hot water. Mix well and let stand for several days. Keep in kettle or receptacle and apply as hot as possible with a whitewash or paint brush.

Anderson Fuel-Oil Burner

In burning fuel oil its atomization must be thorough, and in order to attain this result a proper burner must be used and the more simple its construction the better. Oil burners are of two types, inside and outside mixing. In the former the oil and steam come in contact inside of the burner and the mixture is atomized in passing through the burner nozzle. In the latter type the steam passes through a narrow slot or through a series of small holes below a similar slot through which the oil flows, the oil being picked up by the steam outside of the burner and thus atomized by it.

An oil burner of the inside-mixing type has recently been perfected by the N. C. Davison Gas Burner and Welding Co., 3145 Penn Ave., Pittsburgh, Penn.

The device consists of a central cone *A* with an oil opening *B* through the center. The oil is atomized by air or steam that is admitted through the cone-shaped opening *C* surrounding the oil cone. The air or steam crosses the oil just at the mouth of the nozzle *A* and atomizes the oil, so that immediate combustion takes place without smoke, even in a cold furnace. The flames



SECTION THROUGH THE ANDERSON OIL BURNER

can be cut down to 1 ft. in length or increased to as much as 18 ft. The burner is simple in construction and is easily operated. The needle valves *D* and *E* are for hand-controlling the oil and air supply respectively.

As a matter of fact, three types of oil burners are made. The first is a straight oil burner in which air or steam is used for atomizing. For this purpose a pressure of from 30 to 100 lb. of air or steam is used and an oil pressure of from 5 to 50 lb. Then there is a combination oil and gas burner for use where gas can be had part of the time. Air for gas is supplied at from 4 to 8 oz. and high-pressure air or steam when using oil. The third type of burner is for oil when air at low pressure is used for atomizing. This air can be used at a pressure of from 6 to 10 oz. This burner is made either for straight oil burning or for a combination of oil and gas, both fuels being supplied with the low-pressure air.

These burners are suitable for use under steam boilers, with openhearth furnace-ingot and billet furnaces, core ovens and all types of down-draft kilns and ovens. Wherever coal, coke or gas is used, the burner is adaptable.

From Superheated Steam to Blast-Furnace Gas Engines

By A. L. Fritz

Converting an experienced steam-engine operator into a blast-furnace gas-engine operator cannot be thoroughly accomplished in a few days' time. From superheated steam to blast-furnace gas is a long, hard jump, and having measured the distance, so to speak, I know that it is a hard proposition.

After operating cross-compound horizontal-vertical steam engines for five years, I was suddenly transferred to a blast-furnace gas-engine room containing four 3000-kw. units, and that yellow transfer card, once it became effective, turned out to be a round-trip ticket to His Satanic Majesty's winter resort.

I was put to break in with an experienced gas-engine operator, and his only fault was his creed, for it was his personal contention that every gas engineer could find out things for himself, because that was how he got his. Such reasoning is good enough if it is not carried to extremes, but that was what he did, with the result that when I began to fight those engines alone I soon found that there were a number of little kinks in my new job that I would have to unravel, and do it mostly on my own initiative.

Of course I was told and shown how to start and stop a unit and also instructed as to the running position of the ignition under normal conditions, but I was not told anything about some of the abnormal conditions that eventually made their appearance.

Left Alone With Units in Service

After four days of breaking in, I found myself alone with three units in service and the pilot light signifying that the switchboard operator required the fourth one. This unit had been idle about eight hours, and as blast-furnace gas is very irregular, when I got started up and got the machine in phase, the needle on the indicating meter forgot to stop at its usual position, but passed it going and coming; in other words, the needle went from pin to pin, from nothing to 4000 kw. It required only about five minutes of that swinging load to make the switchboard operator a raving maniac, so to speak.

I tried to quiet the engine down by changing the air intake on the mixing chambers, but the more air levers I moved the more the engine bucked the load. With prematuring and nonexplosions it took but a short time to acquire a severe gas headache, and I began to wish someone else had my work card for the time being.

Conditions got far below anything they were used to (on account of my swinging), and to get me out of a bad hole my former instructor was called in. He made two trips around the engine, pulled his cap to one side of his head, gazed at the meter needle and it suddenly stopped its wild rampage and indicated 2800 kw. I asked the gentleman what was wrong and what he did to rectify it, and he curtly replied, "nothing."

I knew right then that he didn't carry a paid-up membership in any "Honest Jawn Club," and I also knew that it was up to me to "get onto" what I didn't know.

After weeks of hard, bitter scrambling, coupled with many a gas head, I learned to really handle the engines. During this time I learned something of the ill temper of such a machine, and it dawned on me that the gas engineer really earned his extra dollar per turn above the steam operator's rate.

My relief was an experienced operator, and although he told me very little, he always left the watch shipshape, and I acquired the blue-chalk habit. For instance, I had a chalk mark on all the air levers on the mixing chambers, and if a unit got to swinging, I could change the air; and if it didn't get results, I could put it back where it belonged. In this way I usually found the trouble before I got around to the last lever.

Locating the Cause of Trouble

Sometimes it would be a dirty brush on the ignition, a grounded ignitor, or a fuse blown out, and once in a while a unit would swing on account of too much cold circulating water. Again, it might swing on account of a shoe slipping down on a multiplying lever on an air-inlet valve; a brush-holder might work loose, letting the brush get out of line with the commutator, thus making the contact too early or too late on that ignitor and therefore causing a jerk in the load.

I gradually learned to judge conditions, and eventually I got the whip hand over the operating kinks that go to make the gas-engine log sheet look good to the "Old Man." I found out that by keeping the circulating water at a normal temperature in the pistons and cylinder jackets and a regular oil feed for cylinder lubrication, my trouble invariably dwindled down to air mixture.

It is important, in gas-engine operation, to govern the amount of lubrication closely and to be sure it is not fed hit-and-miss, but a drop in each spray to every three turns of the layshaft, for instance. Furthermore, increase the oil feed on a cylinder if it gets to backfiring very much, as backfiring causes dry spots on the cylinder walls and pistons; but do not flood a piston to remove a black spot; use a few applications of kerosene and then adjust the lubricating oil to that individual unit.

Watch the clearance on the inlet- and the exhaust-valve lifts and see that there is at least a $\frac{1}{16}$-in. clearance. Keep the gas lift equalized on all inlet valves and also keep the ignition equalized on both sides of the engine. See that the swing joints do not leak and ruin the oil circulation. Try both oil pumps every day on each unit to see that they are in order and keep the expansion joints tight.

Operator Must Learn Pulse of Engine

It is up to the operator to learn the pulse of each engine, for the natural circumstance under which a gas engine operates tends to work things loose—a great deal more so than the even pulsing stroke of a steam engine—and it pays to thoroughly inspect each unit frequently.

And last but not least, by all means cultivate the good will of the switchboard operator; cater to his professional hobbies relative to gas engines. His job is no sinecure, for gas engines make his a hard task, and if his ethics of coöperation are the least bit below par, he can make life miserable for the unfortunate who happens to be the man behind the throttle on a blast-furnace gas engine.

Current-Transformer Connections

By W. R. WOODWARD
Engineer, Westinghouse Electric and Manufacturing Co., East Pittsburgh, Penn.

A description is given of two types of current-transformer construction, and then the reverse "V" and the star connections of this type of apparatus are discussed.

CURRENT transformers are used for one or both of two purposes; namely, to reduce the current in the circuit to a value suitable for use with instruments or to insulate the instruments from the high-tension circuit. They are so designed that the secondary current is a definite proportion of the primary current for practically any value of primary current which may flow.

The current transformer is simple in construction, consisting of a primary and a secondary winding, both of which inclose a laminated iron core. The primary winding consists of a large number of turns of comparatively small wire, when the transformer is built for a low current (say 10 to 5 amperes) and of a small number of turns of heavy wire or strap when built for a large current (say 100 to 5 amperes). The secondary is usually wound for 5 amperes and has a large number of turns of about No. 12 wire.

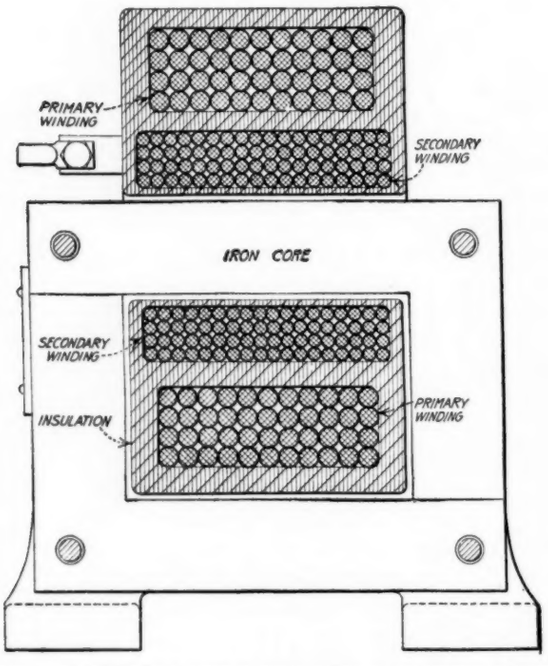


FIG. 1. SECTIONAL VIEW THROUGH A COMMON TYPE OF CURRENT TRANSFORMER

If the primary winding is to be used in a high-tension line, it is insulated from both the core and secondary winding, as shown in Fig. 1, which gives a cross-sectional view of a typical transformer. Figs. 3 and 4 are general views of the same piece of equipment. Fig. 3 is for stationary service, and Fig. 4 is a similar piece of equipment to that shown in Fig. 3, fitted with a handle to make it portable. Terminals *P* are the primary and *S* the secondary. A maximum voltage rating is usually given on the nameplate, which merely indicates the strength of the insulation, and the transformer must not be used on voltages above that rating, but may be used on any voltage below it. For instance, a transformer marked 6900 volts maximum may be used on a 2300- or 110-volt circuit, but not on an 11,000-volt circuit.

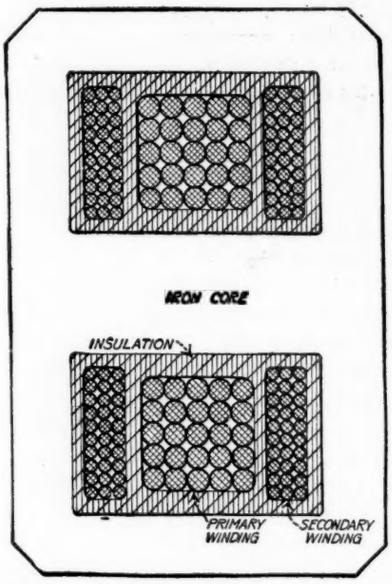


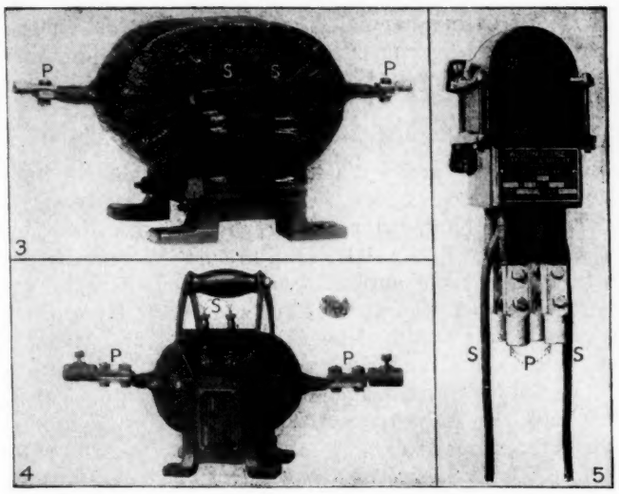
FIG. 2. SECTION THROUGH CURRENT TRANSFORMER USED FOR EITHER LOW OR VERY HIGH VOLTAGES

In a particular type of current transformer, such as shown in Figs. 1 and 3, the number of secondary turns is practically the same for any ratio, the only difference between transformers of different ratios being the number of primary turns and size of primary conductors.

Figs. 2 and 5 are a cross-sectional view and a general view of another type of current transformer having a different arrangement of winding and core to that in Figs, 1, 3 and 4. This type is commonly used for low voltages, 2300 or less, and also for very high voltages, 33,000 and above. It is suitable only for designs where the primary leads can both be conveniently brought out from the same end of the transformer, as in house wiring, where a transformer is installed on low voltage for a watt-hour meter or for high-voltage, oil-insulated transformers. The type, Fig. 3, is better where the primary leads are arranged to come out at opposite ends and is convenient for switchboard mounting.

The action of a current transformer can best be understood by remembering that in any transformer the current flowing in the secondary winding flows around the core in a direction opposite to that flowing in the primary and that the secondary ampere-turns (current $\times$ turns) are practically equal to the primary ampere-turns. The reason they are not equal is that the primary winding also carries the exciting current. In the current transformer the proper ratio is

obtained by changing the primary turns as mentioned in the foregoing, and the error due to the exciting current is reduced to a small value by working the iron circuit at a much lower magnetic density than is common practice in ordinary constant-potential transformers. The magnetic density in the iron, and consequently the exciting current and ratio value, depend upon the impedance of the meter load connected to the secondary of the transformer.



FIGS. 3 TO 5. TYPES OF CURRENT TRANSFORMERS

If a large number of meters having a high resistance or impedance are connected to the transformers, a considerable voltage is necessary to make the current flow through the meters. To develop this voltage a certain flux must pass through the magnetic circuit, which in turn requires primary exciting current or ampere-turns which are not reproduced in the secondary winding. If the number of meters be reduced, the voltage developed in the secondary winding becomes less, thereby reducing the exciting current and improving the ratio. The secondary voltage developed will always be only the amount required to force the secondary current through the meter load. If the secondary resistance be increased to infinity (that is, becomes open-circuited), the secondary voltage will rise to the maximum (that is, the iron will become saturated). This will cause the iron to heat up, and the voltage across the secondary terminals becomes very dangerous.

A single-phase circuit having a current transformer T is shown in Fig. 6, where L represents the load of the circuit and I the current flowing in the direction shown by the arrowheads at a particular instant. The meter M, connected in the secondary of the current transformer, has a scale marked to indicate the current flowing through the load, thereby taking account of the ratio of transformation in the current transformer. The meter M therefore reads exactly the same current a direct-reading meter would if connected in the line at point A.

The connections of current transformers on polyphase circuits are in some cases rather complicated; in this article, however, the more common connections will be considered in detail.

The most common connection for three-phase three-wire circuits is the reversed "V" connection shown in Fig. 7, in which two current transformers T and T' may be used to indicate the current in all three wires. The current from the transformer in phase A flows through instruments L and M and, so far as instrument L is concerned, is essentially a single-phase connection, therefore instrument L will indicate the current in the line A. Similarly, the current from the transformer in phase C flows through instruments N and M, therefore instrument N indicates the current in line C. The combination of the currents flowing through meters L and N passes through meter M; this will cause the latter to indicate the current in line B. This fact is illustrated by the vector diagram in Fig. 8.

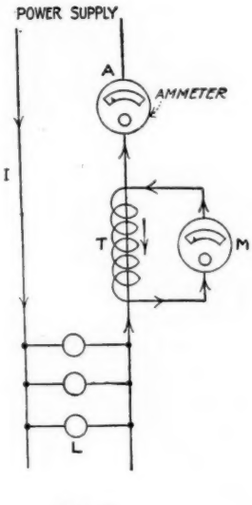


FIG. 6

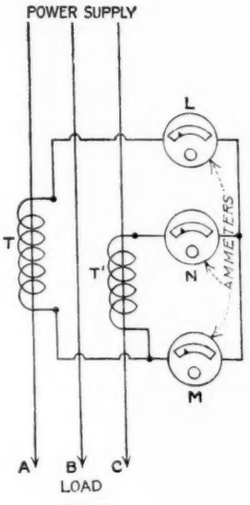


FIG. 7

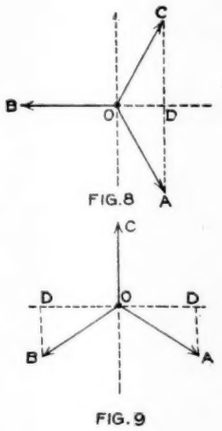


FIG. 9

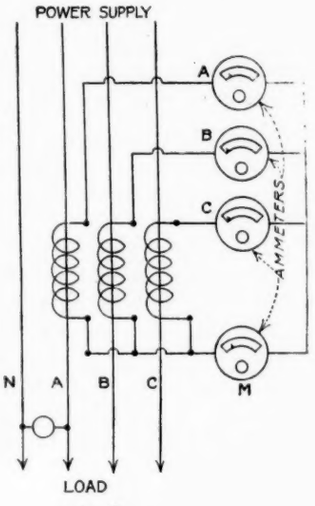


FIG. 10

FIGS. 6 TO 10. CURRENT-TRANSFORMER CONNECTIONS, AND VECTOR DIAGRAMS SHOWING THE CURRENT RELATIONS OF CURRENT TRANSFORMERS CONNECTED IN A THREE-PHASE CIRCUIT

In considering the vector diagram, Fig. 8, let it be assumed that when the arrows point to the right the current is flowing in a particular direction which will be called positive, and when the arrows are pointing to the left it is flowing in the opposite direction, or negative. When the arrows point up or down, the current

will therefore be zero, and the value of current in any line will be proportional to the distance from the vertical line drawn through *O* to the point of the arrow.

The currents in the lines *A* and *C* are represented in Fig 8 as both being positive and each to be one-half their maximum value; that is, their projection on the horizontal axis, or distance *OD*. The current in line *B* is represented as being negative and at its maximum value. Now the law of electric currents, known as Kirchhoff's Law, is that at a junction of conductors, such as at *O*, the sum of the positive and negative currents is zero; that is, any current flowing into this point on one or more conductors is equal to the current flowing out of the same point on one or more other conductors. The current in *B*, being negative, flows toward the point *O*, and is, therefore, equal to currents *A* and *B*, flowing away from this point. Therefore the current in line *B* is the vector sum of the currents in the lines *A* and *C*. Now, since the currents in the instruments *L* and *N* are exactly proportional to the currents in the lines *A* and *C*, the current in *M* must be proportional to the current in *B*.

In Fig. 9 the current in *C* is illustrated as being zero, and at that instant the currents in *B* and *A* are equal. The current in instrument *N* is, therefore, zero, and since the current from *A* flows through the meters *L* and *M*, their readings are necessarily equal, which, as can be seen from the diagram, is necessarily the case, since the projections of *OA* and *OB* on the horizontal are equal.

This connection for instruments may be used for ammeters, relays, trip coils, the current coils of wattmeters or power-factor meters, and, in fact, any current carrying coil whatsoever. However, there are some objections to using this connection for protective relays and trip coils, which will be considered later in a discussion of the "Z" connection.

Meter Indication Also Correct for Unbalanced Condition

In the foregoing we have considered that the three-phase load was perfectly balanced. The indication of the meters, however, will be correct as well for any unbalanced condition. The worst unbalancing possible is to have a single-phase load on two wires, with no load on the third. Suppose a single-phase load is connected across wires *A* and *B*, the currents in the two legs of the circuit will then be in direct opposition to each other; that is, if the current in *A* is positive, the current in *B* will be negative and of the same value. The current from transformer *T* will flow through instruments *L* and *M*, indicating an equal load on wires *A* and *B*, and no current will flow in *N*, indicating no current in *C*.

Suppose, again, that a single-phase load is connected to lines *A* and *C*. The current from line *A* will flow through instruments *L* and *M* as before, and current from line *C* will flow through instruments *M* and *N*. These currents tend to flow through instrument *M* in opposite directions and, being equal, are canceled. Instrument *M*, therefore, indicates zero current in line *B*, which is correct.

In case of a three-phase four-wire system, it is necessary to use three transformers, which are usually connected in "Y" or star, as shown in Fig. 10. Since it is possible for some load to be connected between one phase and the neutral, such as between *A* and *N* as shown, the current on the other phases is thereby unbalanced so that it is necessary to use three transformers. With the connections as shown, each instrument being connected to a transformer in each phase, the operation is essentially the same as for single-phase. The current which flows in *A* does not necessarily flow in *B* and *C*, but a portion may be carried off on the line *N*. The instrument at *M* will indicate the value of current flowing in the neutral wire *N*.

Burning Rhode Island Anthracite

According to a report issued by the Locomotive Pulverized Fuel Co., of New York City, tests were recently made at Olyphant, Penn., with regard to the utilization of pulverized Rhode Island anthracite in comparison with Pennsylvania anthracite. The Rhode Island coal used was mined near the surface and before being prepared for the test had been lying exposed to winter weather, so that the moisture content was high.

The tests were conducted on a 465-hp. Stirling boiler that had been in regular service with pulverized Pennsylvania anthracite as fuel. About six tons of the pulverized Rhode Island coal was substituted during the regular operation of the boiler, with no changes in the furnace, feeding equipment or operating adjustments, to compare the combustion results. No difficulty was experienced and the combustion was satisfactory.

A second test was made to determine the relative combustion and boiler efficiency, under approximately the same operating conditions, with Pennsylvania anthracite bird's-eye and Rhode Island anthracite. The latter fuel burned in practically the same manner as the former, but there was a greater accumulation of ash in the slag pit. The relative properties of the two fuels may be seen from the following:

	Pennsylvania Per Cent.	Rhode Island Per Cent.
Moisture	0 92	0.42
Volatile matter	6 82	6.65
Fixed carbon	74.55	62.75
Ash	18.63	30.60
Sulphur	.....	0.82
Fineness, through 100-mesh	98 00	99.00
Fineness, through 200-mesh	90 00	93.00
Heating value (calculated) B.t.u. per lb. dry coal	11,850	9,785

The comparative results obtained in the tests of the two fuels are given in the following table:

RESULTS OF PULVERIZED FUEL TESTS

	Pennsylvania Anthracite	Rhode Island Anthracite
Duration of test	Continuous	4 hr. 20 min.
Average boiler pressure, gage	141 lb.	140 lb.
Factor of evaporation	0.978	0 991
Horsepower developed	460	386 5
Weight of fuel used	46,096 lb.	8721 lb.
Weight of water evaporated	388,356 lb.	58,300 lb.
Actual evaporation per pound of coal	8.42 lb.	6.68 lb.
Equivalent evaporation from and at 212 deg. F. per pound of coal	8.24 lb.	6.62 lb.
Boiler efficiency, per cent	67.3	65.65

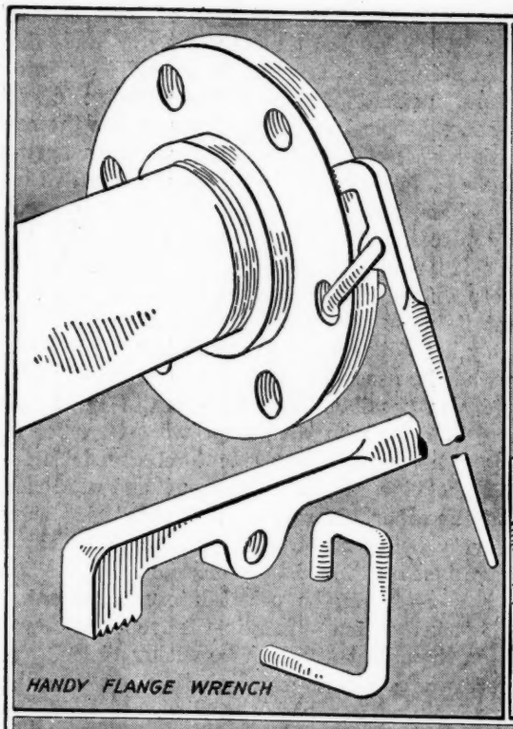
The Rhode Island coal used in the tests was some of the byproduct from mine operations on a tract of graphitic anthracite, which is being worked primarily for graphite. It pulverized and was dried with less difficulty than the Pennsylvania anthracite.

Every Liberty Bond you buy is a safe financial investment in the future happiness and self-respect of your children. Buy as many as you can and let them inherit as good a country as you did.

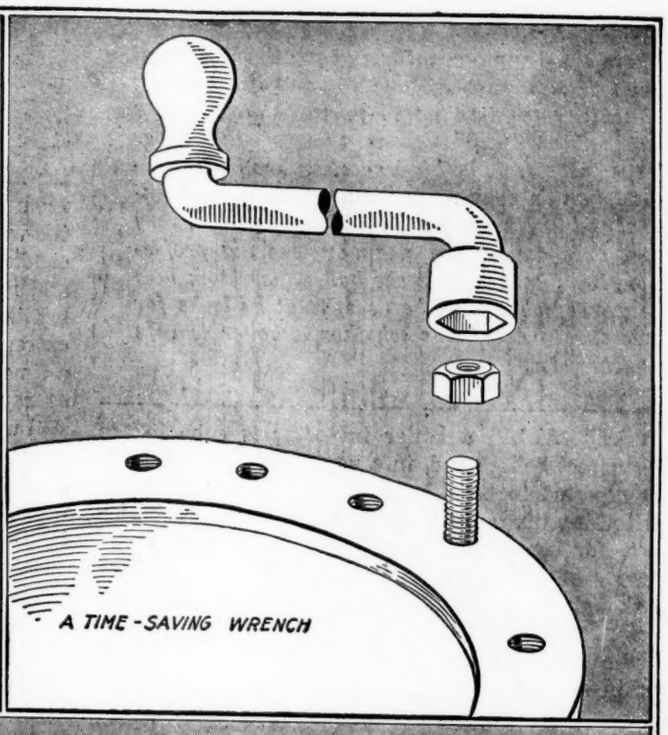
Bondholders, don't shout until you are out of the war woods. The danger is still here. Buy bonds until the war is over.

From an Engineer's Notebook

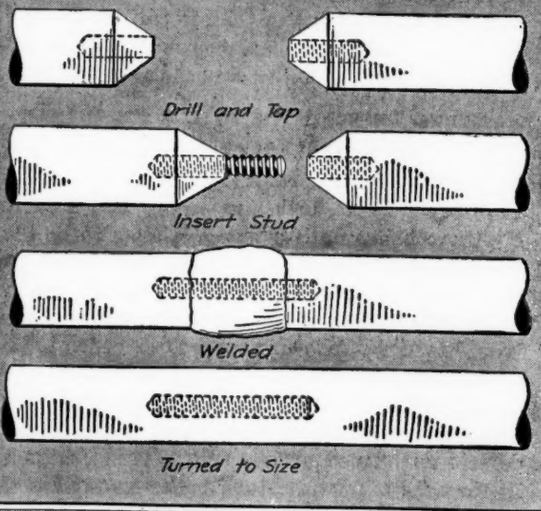
By M. P. Bertrande

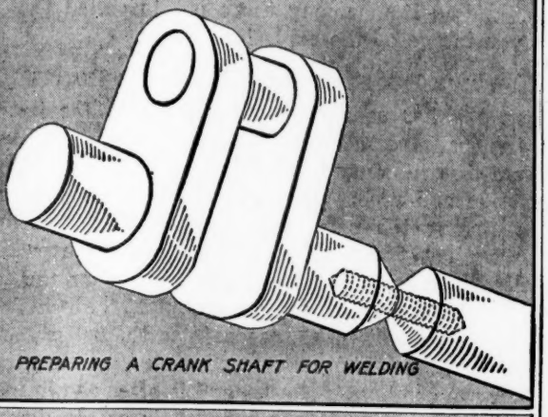


HANDY FLANGE WRENCH

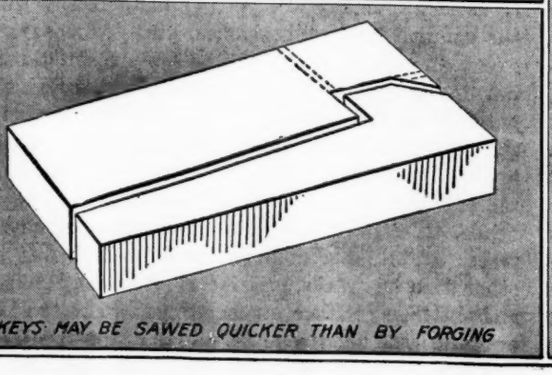


A TIME-SAVING WRENCH

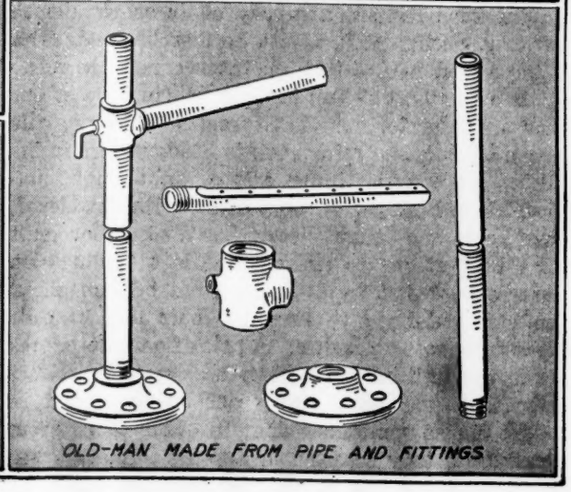




PREPARING A CRANK SHAFT FOR WELDING



KEYS MAY BE SAWED QUICKER THAN BY FORGING



OLD-MAN MADE FROM PIPE AND FITTINGS

The Boiler Inspector's Work

By M. T. GLENN

There are many occupations of which the general public knows practically nothing and of the details of which men in kindred pursuits have only a vague idea. One such is that of the boiler inspector. While boiler inspection has been practiced in this country for more than a half century and in Europe for a still longer period, very few, even among the steam-engineering profession, know much about the boiler inspector; how he works, what tools he uses, what he looks for in order to determine whether a boiler is safe or otherwise.

NATURALLY, a boiler inspector is supposed to inspect boilers and, in a vague sort of way, he is expected to be able to predict when a boiler is going to blow up. This latter supposition is not exactly correct, for sometimes an old vessel will display the perversity of inanimate objects and refuse to explode even though it is continued in service long after the inspector "condemns" it and the insurance is cancelled. That the inspector does give timely warning of the impending danger is attested by the fact that comparatively few boilers explode notwithstanding the increasing number in service. Not all boilers are insured or inspected, and it is among those not inspected that a large percentage of the explosions occur.

How the Inspector Goes About His Duties

When a boiler user signs an application for insurance, the insurance company notifies one of its inspectors, and it is his duty to examine the boiler or boilers in question and report upon the construction and condition, stating the safe working pressure. The inspector notifies the plant of the date of his expected arrival early enough to permit preparation for the inspection. He finds his way to the plant (which frequently is a difficult task), proceeds to the boiler room to see if everything is in readiness for him, then inquires where he can change his clothes and is often shown into the engine room, where a greasy chair or workbench serves for a clothes rack. Here he disrobes and, since safety is second nature to him, takes care to leave no money or other valuables in his clothes (in at least one instance an inspector's clothes disappeared during his absence and he had to return to his headquarters in his overalls). He dons an inner suit of light-weight material which is highly absorbent and readily laundered, a pair of socks and rough shoes; then a special oversuit that has boot straps to prevent the legs "riding" up and interfering when he is backing out of a manhole, and an attached hood to keep the hair and back of neck free from soot and ashes. A pair of gauntlet gloves completes the uniform, and he is an object to attract attention whenever he ventures out on the street in this attire, as he sometimes does in order to go from one plant to another near-by.

For an internal inspection the following outfit is required: A small cross-peen hammer, a test pump and gage, and a light. The best type of light to use for this work is a subject of much controversy, and it might be well to digress a few moments and look into the merits and demerits of some of them. Some inspectors prefer the old-style "tallow dip"; others use the candle, but with a special holder which feeds by a spring in the handle so that the light remains about twelve inches from the hand and can thus be introduced into out-of-the-way places. There is a serious objection to the candle aside from the fact that it is becoming more and more difficult to obtain and does not give a very brilliant light, it sometimes melts very quickly in an extremely hot boiler and leaves one in the dark just at a time when he needs a light badly to see how to get out as rapidly as possible. Another type of light that is still used by some who have inspected boilers for many years is a home-made kerosene torch consisting of a piece of gas pipe capped at one end and stuffed with waste at the other. Kerosene oil is obtainable at practically every boiler room, and this "flambeau" has the advantage just mentioned in connection with the special candle holder—it can be poked into narrow crannies, but it is "smelly" and shines in the inspector's eyes as well as on the object at which he wishes to look. Most inspectors prefer either the flash light or the miner's acetylene lamp. They both throw a good light in the desired direction without any back glare. The former is rather expensive to use, and batteries are less easily obtained in small towns than is carbide for the miner's lamp; but it does not have to be cleaned and filled every time it is used, as is the case with the gas light.

Other Things Needed for a First Inspection

But to return to the inspector's outfit, if it is a "first inspection," he will require, in addition to the articles mentioned, a rule, a thickness gage and a pad and pencil, there being no less than 75 items to be filled in on the data sheet for an ordinary horizontal-tubular boiler. It is a matter of habit with an inspector which portion of the boiler he examines first and what sequence he follows, hence the following method or order is given only as an illustration without being set up as an example of the best procedure. Let us assume that he first crawls through the fire-door onto the grates and looks for such defects as burned or blistered plates, cracks or leaks. In the case of a water-tube boiler he strikes the tubes to ascertain if any are getting dangerously thin, notes the condition of walls, baffles, etc., to be sure that no great amount of cold air enters except through the burning fuel and that the gases are directed along the path the designer intended them to take. He then enters the rear clean-out door, gives the same attention to the fire surfaces and setting as at the front end, then enters the boiler by the upper manhole and examines the shell, heads, tubes and braces for such conditions as scale, traces of oil, corrosion in its various forms and any other defects, cracks, missing rivet heads, broken braces and the like. Before leaving this part of the boiler, he examines the feed pipe to see that the opening in its end is clear and that it does not discharge near a seam, plate or tube, and also inspects the other openings to

outer attachments. When he enters the lower manhole, he looks for sediment or scale, oil and corrosion, also for indications of burned or cracked plates, which are sometimes seen better from the inside on account of the soot on the fire surfaces, sees that braces are not slack and that the blowoff opening is clear. If there are water tubes, the caps of some of them at least should be removed so that he may obtain an idea of the condition of the whole.

Finishing the boiler proper, he turns his attention to the attachments. The steam gage is taken down and tested; if found incorrect, it is adjusted if possible or a new one ordered. Before the gage is replaced, he blows through the small pipe and connecting valve to be sure that they are unobstructed. The safety valve can be examined only superficially at best when there is no pressure on the boiler, but the inspector endeavors to see the spring, if it is a pop valve, to assure himself that it has not been compressed too closely and that the valve should perform its function. Fortunately, a pop valve seldom gets out of order, and the best way to "fix" a defective one is with a new one and thus be on the side of safety.

The inspector calculates the safe working pressure, taking into consideration age and condition, which enter largely when a boiler has been in operation for considerable time unless the conditions are practically ideal. Mailing in his report and data with a recommendation completes the first inspection.

The Proper Way to Prepare a Boiler for Inspection

In making ready for inspection the fire is first drawn and the pressure permitted to fall to 15 lb. or less, while the ashes and clinkers are removed from the grates and bridge-wall and the soot and ashes from the combustion chamber. When the setting is sufficiently cool to preclude the possibility of damaging the empty boiler, and after the tubes have been blown and fire surfaces swept, the blowoff valve is opened wide and all the water is blown out. Next in order comes the removal of the manhole plates; the top one should be taken off first if the boiler is of the water-tube type, and the blowoff valve should not be closed until this plate is off, unless the boiler is vented by some other means to prevent a vacuum being formed. In opening a horizontal-tubular boiler, the following method should be followed to avoid scalding the one who removes the top manhole plate: Open the lower manhole, close the flue doors and open the damper. The top manhole may now be removed with impunity as the stack draft will draw the steam downward as soon as the joint is broken. Finally, the rear clean-out door and fire-doors are closed, the ashpit doors opened and the boiler left to cool. It will be noticed that with this arrangement the stack draft draws a current of air through the top manhole and then cools much of the water surfaces on its way to the stack via the lower manhole, while another air current enters the ashpit doors and cools the setting and fire surfaces of the boiler. As there is no way to induce this air current except by the aid of the stack draft, it is necessary that the large doors in front be kept closed. Since there is no connection between the water surfaces and the draft in the case of the water-tube type of boiler, it requires more time to cool, but the same method applies regarding the air cooling of the setting and fire surfaces.

Referring to the attention attracted by a boiler inspector while in his suit, the writer was once mistaken for a highwayman, although he did not know it at the time and only learned of it through conversation with a relative of the other party. After inspecting several boilers, he received a message from the office of the mill to come up and answer a long-distance telephone call. He went to the office and, entering through the back door, found himself in a reserved enclosure where the only person in the place was making out the payroll, having, spread out on his desk, several hundred dollars in currency. It was not till some months later that the inspector was told that the cashier confessed that the unexpected appearance of the boiler inspector nearly caused him to have an attack of heart failure, as he mistook him for a robber and was resigned to his fate.

The Inspector Finds Himself in an Embarrassing Position

The writer was once mistaken for an inmate of an institution known as the State Hospital for the Insane, although this time he was not dressed in the suit described, but was clothed in his street garb and right mind. Only a fortunate chance prevented his having to spend the night in a ward. After calling the gentleman in charge of the buildings and equipment by telephone and making arrangements to inspect a couple of the boilers, the inspector walked into the grounds through the only gate available, spoke to the gateman and asked where Mr. Blank could be found. Following directions, he found that gentleman and was intrusted with a key to a spare room in which to change his clothes and was told, "Just leave the key with the gateman, I will probably be gone for the day." After finishing his work and changing to his street clothes, the inspector started for home and was a little disturbed to note from a distance that the gateman had been changed since he entered. As he approached the gate, the attendant walked out from his shady bench and intercepted him. He proffered the key and told the man that Mr. Blank had requested him to leave it with the gateman when he left. That worthy had had plenty of experience with the wiles of inmates and their cunning attempts to escape, so without appearing to think it at all strange he accepted the key and promised to see that Mr. Blank got it when he came in the morning, but without in the least relaxing his vigilance or letting the inspector get between him and the open gate. The inspector, in his turn, was careful to make no false move which might lead the gateman to think he belonged inside, hence when the gateman suggested that he go over and have a seat in the shade and take a drink (water—this happened in a "bone-dry" state), he accepted with as good grace as possible and even accepted the proffered afternoon paper, although he used it more to hide his growing uneasiness while forming schemes for outwitting the man near-by and affecting his "get-away" than for reading. Fortunately, a diversion occurred which he guessed might give him time to think more clearly. A medical student serving as an interne at night came in and stopped to pass the time of day with the gateman. Seeing the suspect sitting near-by, he said, "Good evening." The inspector returned the greeting but without much spirit, and when the gateman asked the student if he knew "this man", the inspector thought, "Why, he

wouldn't know me from Adam," but was agreeably surprised when the student replied, "Yes, I know him. He is the boiler inspector. I met him and Mr. Blank along the boiler-room walk several days ago." Thus the situation was suddenly relieved for both the inspector and the gateman, who hastily apologized.

The following is an illustration of how little some men know about boilers. An insurance company sent a telegram instructing their inspector in the district to investigate damage to a boiler at an oil mill in a small town, appending the words, "See Mr. Light." On arriving at the oil mill, the inspector accordingly asked for the gentlemen named and was invited into the back office for a confidential talk in which he was told that the mill, which was owned by the speaker, had been leased to a corporation by which he was employed as manager. He had retained his insurance policy on the boilers, and now that one of them was leaking badly around the tubes at the rear end, he feared that the engineer had neglected his business and that the water had been allowed to get low. Mr. Light asked the inspector to examine the boiler and report to him, saying nothing to the other employees around the plant. Upon investigating the interior of the offending vessel, the inspector found scale caked between the tubes several feet from the rear, making a solid mass all the way back to the head, thus preventing water from circulating around the tubes and cooling them and the head. When he reported to Mr. Light that the water had not been allowed to get low and that scale accumulating between the tubes had caused the trouble and must be removed before the boiler was fired any more, that gentleman thanked him and said, "I'm mighty glad to know that it was not neglect on the part of the engineering force. We will have the scale removed."

Why Coils Sometimes Fail To Heat

When pipe coils are used for heating, in conjunction with radiators, it is sometimes noticed that circulation through the coils is not good, especially if they are long and made of small pipe connected up with return bends instead of headers. The reason is the greater resistance of the coil, since the steam must traverse a greater distance. Sometimes a coil will heat at both ends but not all over. This is because steam enters from the return piping as well as from the supply and the air is trapped between the two. The location of the air vent becomes an important matter in such cases.

Waterproofing Porous Material

Brick, stone or cement walls may be rendered waterproof by one or more applications of gasoline in which 5 to 10 per cent. of paraffin wax has been dissolved or cut. The fluid may be applied with a brush or spray pump. It is colorless unless an excessive amount of wax has been used, in which case it will leave a gray color or coating, but coloring matter such as lampblack may be added. The joints of a brick wall may be penciled, then the whole wall gone over with uncolored fluid. The surface should be as dry as possible when the waterproofing is applied, to allow it to penetrate, since the gasoline simply acts as the vehicle to carry the wax into the pores of the material to seal them up. This means of sealing the small pores is also beneficial in reducing air leaks from concrete fan ducts, etc. The disintegration of porous material when exposed to moisture and then to freezing temperature is caused by the irresistible expansive force exerted by the entrapped water in freezing. This of course applies to cement walks and roofing as well, so that waterproofing is beneficial in many ways.

Turner Baffle-Wall Construction

The shapes of the vertical passes in water-tube boilers have been determined largely by the fact that loose tile placed against flame plates were used for the baffle walls. Effort to build an inclined wall to give the theoretically perfect pass resulted in the dislodgment of the tile under the vibration of the tubes, due to the tube cleaners or to the release of the steam bubbles and from the action of soot blower, etc.

Replacing loose tile is a difficult matter, as tile of the original size cannot be used without spreading the tubes temporarily to get the tile in place, and the alternative is to use smaller tile which results in wide-open joints through which the hot gases short-circuit.

With the development of the Turner baffle wall, by

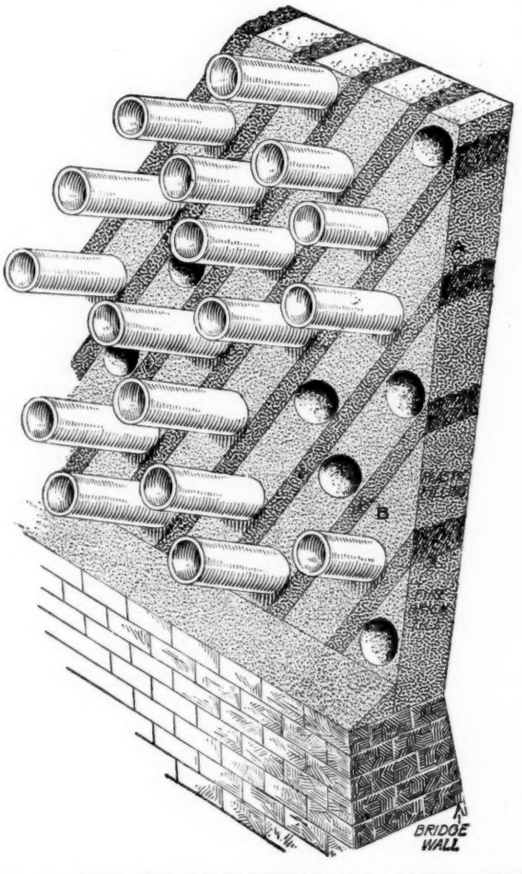


FIG. 1. DETAILS OF BAFFLE-WALL CONSTRUCTION

the Engineer Co., 17 Battery Place, New York City, a construction is provided that eliminates these objectionable features. This wall is built by introducing in the diagonal alleys between the tubes a molded, corrugated tile, dovetailed at the ends. The pockets thus formed by the tubes and the adjacent rows of tile are filled with a plastic material which fills the space no matter

how irregular. This plastic material does not grip the tubes as it shrinks in hardening and leaves a small annular space around them. A tube can be withdrawn when cold and replaced by another. The filling cannot be displaced, however, as it bonds with the corrugations *A* in the tile, and the latter dovetail at each end with each other as at *B*, Fig. 1.

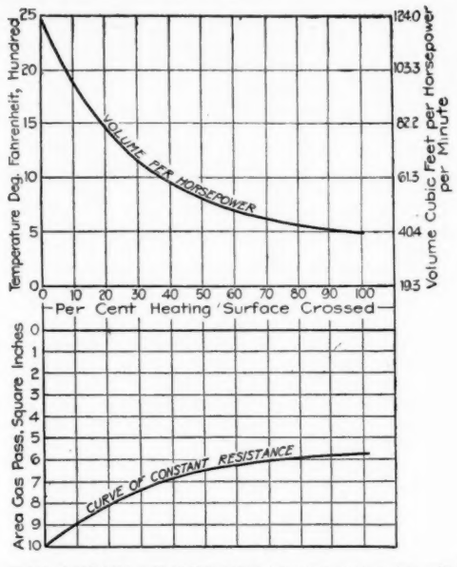

Temperature Deg. Fahrenheit, Hundred
Volume Cubic Feet per Horsepower per Minute
VOLUME PER HORSEPOWER
Per Cent Heating Surface Crossed
Area Gas Pass, Square Inches
CURVE OF CONSTANT RESISTANCE

FIG. 2. TOP CURVE SHOWS RELATION OF GAS TEMPERATURE AND VOLUME; LOWER CURVE, AREA OF GAS PASS; EACH FOR PERCENTAGE OF HEATING SURFACE CROSSED

It is therefore possible to build a practically gas-tight wall at any desired slope through which tubes can be withdrawn and replaced without damage to the wall. No flame plates are necessary.

It has been found an advantage in boiler design to give the gases of combustion as near a uniform velocity through the passes as possible. A study of the curve showing the decrease in volume of these gases due to the cooling effect of the surfaces over which they pass (Fig. 2) shows that with 40 per cent. of the heating surface in the first pass, the area of its outlet should be about 60 per cent. of the area at the bottom. As the cooling effect of the drum and the superheater are comparatively small, the area at the top of the second pass should be somewhat less than that at the top of th first pass and the second pass should also taper.

The third pass shows little cooling effect, and its shape is not so material, so long as ample space is provided for the exit of the gases.

The elevation of the boiler shown in Fig. 3 illustrates the application of these principles. The bridge-wall is moved back to enlarge the furnace chamber and to keep down the furnace temperature. By the location of the bridge-wall the opening of the first pass was established. The Turner wall starts from the bridge-wall and slopes forward at such an angle as to make the top area 60 per cent. of the bottom, the heating surface exposed in first pass being about 40 per cent. of the total.

The rear wall is carried down at right angles to the tubes, it being a matter of judgment as to its slope and how far down to extend it. Some engineers claim it is an advantage to contract the lower end of the second pass so as to increase the velocity of the gases at this point and shoot them well down over the lower rows of tubes and toward the rear end of the boiler. The expansion of the gases on their release also helps to this end, and the reduction in velocity due to the change from passage across the tubes to passage along the tubes, as well as the mushrooming into the space back of the bridge-wall, tends to drop into that space any cinders or soot that would otherwise be carried up the stack.

The advantage over the alternative use of a short section of horizontal baffle on the lower row of tubes running forward from the top of the bridge-wall to the bottom of the ordinary baffle wall, Fig. 3, is evident. First, a larger tube surface is exposed in the first pass to the radiant heat of the fire and to the gases when hottest, tending to increase the capacity and at the same time lower the furnace temperature, since the heat goes into the water instead of the setting. Second, a flat surface and not an elbow with a joint impossible to keep tight with the inevitable expansion and contraction of the horizontal baffle is presented to the flames. Third, the difficulty of renewing the lower tubes, which are most frequently burned out, is lessened as they carry no horizontal baffles. Fourth, there is no dead angle at the bottom of the second pass where the vertical and the horizontal baffles join. Fifth, there is no leakage as there would be through the horizontal and transverse joints of the horizontal baffles.

Another application of the sloping baffle wall is the downward extension of the rear baffle to lessen cinder

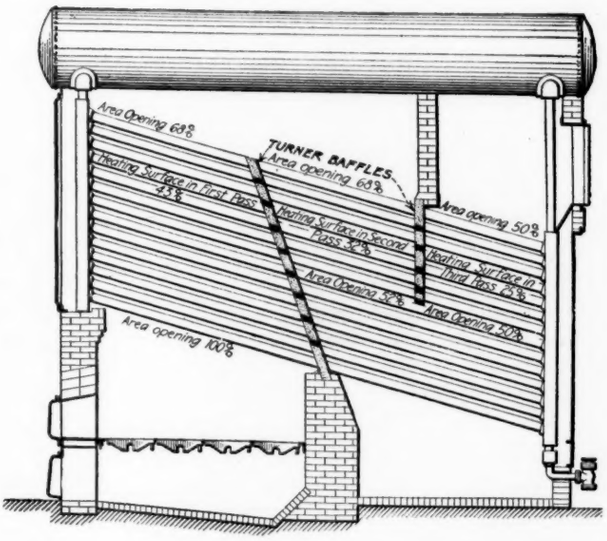


FIG. 3. CONSTRUCTION OF BAFFLE WALLS FOR MAINTAINING UNIFORM GAS VELOCITIES

carrying by reason of the change in the velocity and by the momentum of the cinders shooting them clear of the gases when the latter turn upward. This action does not take place readily when the turn is made among the tubes, as the cinders hit the tubes, rebound, are caught up and carried away by the gases.

As a nation we have drafted men to fight for us. That means we have chosen them to suffer hardship and to sacrifice life, if need be, to protect us and our interests. This places upon each one of us an equal obligation to suffer whatever hardships are necessary to give them all the equipment they need for success.

FINANCING THE SECOND YEAR OF THE WAR

Share of Yearly Incomes Contributable in Taxes and Bond Purchases

Distribution of incomes of $3,000 and over based on income tax returns for 1916; below $3,000 on carefully made estimates

Column I Family Income Group	II Average Family Income	III Percentage Contributable by Each Family	IV Amount Contributable by Each Family	V Number of Families in Group	VI Total Income of Families	VII Total Contributable by Families
Under $850*				7,288,000*	$4,703,217,000	$102,773,000
$780 — $910	$850	9.60	$82	3,590,000	3,051,500,000	294,380,000
911 — 1,040	1,000	9.90	99	3,525,000	3,525,000,000	348,975,000
1,041 — 1,170	1,100	10.30	113	2,737,000	3,010,700,000	309,281,000
1,171 — 1,300	1,250	10.80	135	2,262,000	2,827,500,000	305,370,000
1,301 — 1,430	1,350	11.20	151	1,826,000	2,465,100,000	275,726,000
1,431 — 1,560	1,500	11.70	175	1,602,000	2,403,000,000	280,350,000
1,561 — 1,690	1,600	12.20	195	1,228,000	1,964,800,000	239,460,000
1,691 — 1,820	1,750	12.60	220	710,000	,242,500,000	156,200,000
1,821 — 1,950	1,900	13.20	251	475,000	902,500,000	119,225,000
1,951 — 2,080	2,000	13.50	270	385,000	770,000,000	103,950,000
2,081 — 2,210	2,150	14.00	301	306,000	657,900,000	92,106,000
2,211 — 2,340	2,275	14.50	330	243,000	552,825,000	80,190,000
2,341 — 2,470	2,400	15.00	360	189,000	453,600,000	68,040,000
2,471 — 2,600	2,550	15.40	393	142,000	362,100,000	55,806,000
2,601 — 2,860	2,750	16.10	443	200,000	550,000,000	88,600,000
2,861 — 3,000	3,000	16.90	507	167,000	501,000,000	84,669,000
3,001 — 4,000	3,500	18.80	658	85,000	297,500,000	55,930,000
4,001 — 5,000	4,500	22.40	1,008	72,000	324,000,000	72,576,000
5,001 — 6,000	5,500	25.80	1,419	52,000	286,000,000	73,788,000
6,001 — 7,000	6,500	29.40	1,911	36,500	237,250,000	69,751,000
7,001 — 8,000	7,500	32.80	2,460	26,500	198,750,000	65,190,000
8,001 — 9,000	8,500	36.40	3,094	20,000	170,000,000	61,880,000
9,001 — 10,000	9,500	40.00	3,800	15,500	147,250,000	58,900,000
10,001 — 15,000	12,500	42.00	5,250	45,309	566,362,000	237,872,000
15,001 — 20,000	17,500	45.00	7,870	22,618	395,815,000	178,003,000
20,001 — 25,000	22,500	46.50	10,460	12,953	291,442,000	135,488,000
25,001 — 30,000	27,500	48.00	13,200	8,055	221,512,000	106,326,000
30,001 — 40,000	35,000	51.00	17,850	10,068	352,380,000	179,713,000
40,001 — 50,000	45,000	55.50	25,000	5,611	252,495,000	140,275,000
50,001 — 60,000	55,000	59.10	32,500	3,621	199,155,000	117,682,000
60,001 — 70,000	65,000	61.50	40,000	2,548	165,620,000	101,920,000
70,001 — 80,000	75,000	64.00	48,000	1,787	134,025,000	85,776,000
80,001 — 90,000	85,000	64.70	55,000	1,422	120,870,000	78,210,000
90,001 — 100,000	95,000	66.30	63,000	1,074	102,030,000	67,662,000
100,001 — 150,000	123,000	69.10	85,000	2,900	356,700,000	246,500,000
150,001 — 200,000	174,000	71.50	124,400	1,284	223,416,000	159,729,000
200,001 — 250,000	225,000	72.20	162,500	726	163,350,000	117,975,000
250,001 — 300,000	277,000	73.00	202,210	42,	118,279,000	86,343,000
300,001 — 400,000	345,000	73.70	254,400	469	161,805,000	119,313,000
400,001 — 500,000	448,000	74.50	333,700	245	109,760,000	81,756,000
500,001 —1,000,000	683,000	75.20	513,800	376	256,770,000	193,188,000
1,000,001 —1,500,000	1,106,000	76.00	840,500	97	107,282,000	81,528,000
1,500,001 —2,000,000	1,701,000	76.70	1,305,500	42	71,442,000	54,831,000
2,000,001 —3,000,000	2,459,000	77.50	1,905,700	34	83,606,000	64,793,000
3,000,001 —4,000,000	3,459,000	78.20	2,706,600	14	48,426,000	37,892,000
4,000,001 —5,000,000	4,514,000	79.00	3,566,000	9	40,626,000	32,094,000
5,000,001 and over	10,284,000	79.70	8,201,500	10	102,840,000	82,015,000
Reported non-taxable incomes not apportioned in reports—50% estimated contributable					2,000,000,000	1,000,000,000
FAMILY GROUPS and individuals—their estimated total incomes and ability to contribute				27,304,199	$38.250,000,000	$7,250,000,000
CORPORATIONS and other business enterprises—their estimated total incomes and ability to contribute after dividend distributions					11,750,000,000	2,750,000,000
Total estimated National Income and amount realizable therefrom					$50,000,000,000	$10,000,000,000
BANKS—the share of the burden which they probably must carry. This is not the estimated peak load, but a conservative estimate of the average minimum burden						3,500,000,000
Estimated receipts from direct taxation and bond sales						$13,500,000,000
Estimated receipts from indirect taxes, such as customs, excise taxes, stamp taxes, including sundry receipts						1,500,000,000
COST of Second Year of the War, estimated						$15,000,000,000

*This group is largely composed of individuals.

HOW TO USE THE TABLE: Find your income in Column I. Multiply this by the "percentage contributable,"—Column III. The result is the total amount which you should contribute during a year. Deduct the amount which you pay in taxes—the remainder is the amount of Liberty Bonds which you should buy from income during a year.

Illustration: $5,000 income. Less tax, say $80
$5,000 x 22.4% = $1,120 Bonds to be bought $1,040

$10,000 income. Less tax, say $675
$10,000 x 40% = $4,000 Bonds to be bought $3,325

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Editorials

What Is My Share of the Cost of the War?

HIS or her share in the cost of carrying on this great conflict to make the world a decent place to live in is one of the questions that should be foremost in the minds of every man and woman in this country today. The Bankers Trust Company, of New York City, recently issued a pamphlet, "What is my Share of the Cost of the War," in which the problem of financing the second year of the war is discussed. The analysis set forth in this pamphlet brings the problem home so vividly that it should make every American do more than think; it should make him act. The table on page 624 of this issue is taken from this pamphlet and gives a very comprehensive presentation of the task.

According to the pamphlet, "During the first year of the war the expenditures of the Government have amounted to over nine and a half billion dollars, or more than fourteen times the average expenditures of the seven years previous to the war. The advances which we made to our Allies for the purchase of materials and supplies have accounted for nearly one-half of our total expenditures.

"The expenses for the next twelve months will probably be considerably larger. Congress voted appropriations for the current fiscal year ending June 13, next, of eighteen and three-quarter billion dollars, but the Government has not found it possible to expend this amount of money, and we doubt if such a large amount can be expended in the coming twelve months. We believe that it is safe to estimate the total expenditures for the next twelve months at about fifteen billion dollars; therefore, to raise this amount is the task we are facing."

Regarding the use of the table the pamphlet points out several things that it is important to keep in mind. One of these is: "The calculations, except for incomes below eight hundred and fifty dollars, are based on family incomes. This seems fair because most of us live in families and perforce think and act in terms of family income and outgo. It goes without saying, however, that an individual without family responsibilities can contribute proportionately more from a given income than the head of a family can contribute or than a given family group having the same income can contribute." In other words, one is not only to contribute the part set forth in the table, but all that it is possible for him to contribute.

The authors call attention to the fact that "in no better way can there be brought home to one the magnitude of the burden of this war and what it means than to consider conscientiously what constitutes ones fair share of the burden. It is no use to blink at the facts of the case. We may as well face them now and, if we have not already done so, prepare to adjust our affairs so that we can take up the burden. Not for this year alone, but perhaps for next year and then for other years to follow.

"It is obvious that business and methods of living heretofore customary cannot go on as usual. In the last analysis what the Government needs is not money but goods and service. Therefore, to the extent that each one of us curtails his wants and thus releases industrial operatives and goods for war work, he is to that degree giving the greatest assistance to the Government. In this way also individual expenditure is automatically decreased with a corresponding increase available to the Government. It behooves us, therefore, to take stock of our resources and to determine thoughtfully and methodically what is the greatest amount of bonds for which we can arrange to subscribe."

Using the Nation's Lignite Supply

IF YOU will look at the coal map of the United States you will see that the Southwest and the Northwest, particularly the Dakotas, North Dakota especially, contain considerable deposits of lignites. The North Dakota natural lignite has about the following average composition: Moisture, forty per cent.; volatile matter, twenty-five per cent.; fixed carbon, twenty-eight per cent.; ash, seven per cent., the heating value being about 6300 B.t.u. per pound. These sections of the country are remote from the coal fields of the East, and they are distant from the Illinois and Indiana coal fields. When these sections of the country use coal either from the Kentucky, Tennessee or West Virginia fields, or the Pennsylvania field, and from the coal fields of the Middle West, the coal must be transported long distances by rail and the lakes and at considerable cost, which becomes more than a monetary loss during a time of rail congestion. National economics, therefore, seems to dictate that the industries adjacent to the lignite fields should learn how to burn this fuel. Lignite in a natural state cannot be transported even short distances from the mines for the reason that the moisture evaporates, causing the lignite to break up into small chunks and flakes and, if subjected to much jarring, it disintegrates into powder, all of which makes the fuel inconvenient to handle.

While commendable progress has been made in the use of lignites, they are not used on a large scale, even by the industries adjacent to the lignite fields. Experience has shown, however, that lignites can be burned under boiler furnaces without insurmountable difficulty. An electric company in Colorado, for example, has been successful in burning natural lignites on an underfeed stoker, the stoker enabling the boiler to develop ratings up to 300 per cent. of normal, and to be able to put the boiler on the line under full boiler pressure from a fire at dead bank in five to seven minutes. This is a boiler installation of the usual kind; that is, the boiler is not overstokered. Altogether, experience in this Colorado

station has shown that even with the ordinary type of underfeed stoker in a boiler setting not especially designed for lignite fuels, great flexibility in boiler output is possible. During the fuel crisis of last winter, the people of North Dakota successfully burned lignite in house-heating boilers and stoves. The experience in Colorado and North Dakota, together with that in Texas, where lignites abound, shows that the lignites may be burned under boilers used for power purposes.

It is likely that experience will dictate that the natural lignites be carbonized; that is, that the moisture particularly be driven off before the fuel is transported long distances. The carbonized lignite presents no difficulty in burning under power boilers.

Elsewhere in this issue Henry Kreisinger, engineer of the Bureau of Mines, and well known for his work on combustion in boilers, has a most interesting article on the combustion of North Dakota lignite, with suggestions for the design of furnaces to burn this fuel. It is interesting to note that combustion is limited to the first three or four inches of the fuel bed of a lignite fire and that the CO_2 is rapidly and completely reduced to CO within the first four of the fuel bed. This, of course, makes necessary the introduction of oxygen or air above and against the fuel bed in order that the CO may be burned to CO_2. It is interesting to note, also, that the reduction of the CO_2 to CO near the surface of the fuel bed is such a heat-absorbing process that the surface of the fuel bed under ordinary conditions is a dull red. With a natural lignite, the absorption of heat by the moisture is a factor in causing combustion to be slow at the surface of a lignite fuel bed.

It is of particular interest to note that the author is of the opinion that an ordinary horizontal grate is unsuited to lignite and that a step grate should be used. The step grate is best adapted for the reason that the ash may find its way down the grate and will not plug the air spaces which, in a separate grate, may be made very large, as they must necessarily be to burn the lignite with success. The step grate also avoids dropping the ash and combustible into the ashpit where, with an ordinary horizontal grate, the ashpit may, when burning lignite, contain more fire than the grate itself.

It is Mr. Kreisinger's opinion that a chain grate, if inclined about fifteen degrees toward the refuse end, and set in a furnace having a long combustion arch extending from the rear far forward in order to drive the flame down upon the incoming coal which, of course, is high in moisture, will successfully burn natural lignite. Directing the flame forward is intended to drive off the moisture from the incoming green coal. We are sure that Mr. Kreisinger's article will add appreciably to the literature on this subject and that the results of his investigations will prove of material value to those engaged in designing furnaces for successfully burning the lignite fuels.

It is up to the builders of stokers and furnaces to take advantage of the experiments of the Bureau of Mines and supplement them with research of their own to the end that stokers and furnaces particularly adapted to lignites may be available to industries in and near the vast lignite fields.

We should not be unmindful of the apparent possibilities of burning lignite in powdered form, particularly so in view of the low fusing temperature of the ash, namely, two thousand degrees Fahrenheit. Just what success have the powdered-fuel exponents had burning lignite in pulverized form?

Coal-Saving Nostrums

STILL again we are forced to call attention to the numerous nostrums which are being urged upon the public as fuel savers. There are usually a few sporadic cases in evidence, but the present exceptional conditions with regard to fuel have engendered a veritable epidemic of them. "Kologen" will save, according to the advertisement, from twenty-five to forty per cent. of your coal bills, and you can get enough for fifty cents to treat a ton of coal. A patriot by the name of Schoen will give you a formula for effecting the same result. The formula is water, salt, and "one common chemical," the name of which he sells ordinarily for one dollar. But as every ton of coal saved now helps win the war, he considers it a patriotic duty to spread these instructions as widely as possible; so during the present emergency a silver quarter, "to cover cost," gets it by return mail. It does not seem to have occurred to the aforenamed patriot that it would not take so much space in the advertisement to name the ingredient as to call it "a common chemical," and if it were any good any paper would be glad to print it for its news value.

Meyers' patent compound for saving coal is another. We have analyzed and exposed many of these nostrums. There is no substance which, sprinkled upon coal, can save one-third, one-quarter, one-tenth, or any appreciable proportion of it, except through the psychological process of leading the fireman to expect an improvement and unconsciously to bring it about; and there is no need of paying twenty-five or fifty cents for a canful of cheap chemicals in order to do this.

Will the Coal Shortage Continue?

WASHINGTON cannot conceal the fact that the Fuel Administration and the Railroad Administration are at loggerheads. As a result there is an alarming shortage of bituminous output because of car shortage. Goodness knows, we went through enough distress last winter, some of it unavoidable, much of it avoidable. Are we to face it again? If so, is it to be because some officials want to make a showing on cost sheets? If these men do not want to appear as selfish children, let them cease to be childish. The public is sick of needless messes. It wants coal, it needs it; miners want to work steadily, car builders are not holding back. Let the Railroad Administration drop the bludgeon it holds over Mr. Garfield.

During the period of agitation on the daylight-saving law, which went into effect April 1, many objections were raised against it. However, the reports coming from different quarters would indicate that the evening peak of the central stations is being considerably relieved without adding anything to the morning peak, a coal saving is obtained, and furthermore, what was not expected, it has proved to be a public safety and defense feature—so much so that the executive committee of the United States Chamber of Commerce at a recent meeting was unanimous in its agreement that the measure should be made a permanent one to operate through the year.

Correspondence

Something To Be Proud Of

I am sure that *Power* readers will be interested in some figures on running an ordinary 500-hp. plant during the unusual year of 1917. This is an old plant, started in 1850 as a mill, now furnishing power to eleven tenants, using individually from 3 to 109 hp., and scattered over a property 400 ft. square. Until March we were running both shaft and electric drives, but at that time we cut off all the shaft drive and are now all on electric transmission. During the last year we delivered an average of 365 hp. to the tenants, at a cost of $23,750, or $65 per hp. These figures are so unusually high for those which anyone is willing to publish that readers would be interested in some of the incidental things that go to make up this result.

All the employees of the plant have had their wages increased about 25 per cent. this past year; our payroll was $80 a week for regular running and $9 a week for overtime on maintenance and repairs, making a total of $89 a week, or $4632 for the year. Our coal bill was for 2564 tons at $6.10, or $15,640; our bills for supplies and repairs were $1688. Some of the items of this amount are as follows: Boiler repairs, $451; oils and grease, $135; boiler compound, $65; building repairs, $32; water, $257; stoker and furnace repairs, $138; engine repairs, $16; packing, $37; electrical supplies and repairs, $144; pipe, valves and fittings, $109. Taxes and insurance amounted to $900.

We are equipped with water-tube boilers and overfeed stokers, and slide-valve automatic engines, and furnish direct current at 115 volts for both power and lighting.

We burn bituminous slack, which during 1916 cost us $3.10 a ton on the boiler-room floor. During 1917 this coal or other coal bought to fill our requirements cost $6.10 per ton on the boiler-room floor. In addition to this condition, the water evaporation fell from 10 to 8 lb. on account of poor coal, poorly prepared coal or coals of qualities strange to us, which puzzled us to find the best method of firing. It was also necessary for six months to put an extra man in the boiler room on account of these conditions.

Our engines are using 40 lb. of steam per indicated horsepower-power, and the efficiency from the indicated horsepower to the tenant's recording wattmeters is 75 per cent. We delivered 317 hp. to these wattmeters, which was 423 i.hp. at engines. On a steam consumption of 40 lb. this equaled 564 hp. at the boilers at 30 lb. per boiler hp. In addition to this we delivered 48 boiler hp. of live steam, which we recorded with condensation meters. This 612 boiler hp. did not include steam used in feed pumps and stoker engines or condensation in mains. Our boilers were run at about rating, on an average.

Notwithstanding the high costs of power, caused principally by inefficient engines, along with some 35-year old equipment which I have not as yet been able to get rid of, and with high-priced coal, one of our large central stations, which has 30,000 kw. turbines, has been unable to make an interesting proposition to us, practically failing on the one point of heating the buildings. Exhaust steam for heating has saved us where our engines would have thrown us down.

Our figures for building maintenance were: Repair and supply bills, $1382; payroll, $4196; coal, $3910; taxes and insurance, $1500; Total, $10,988.

We have 180,000 sq. ft. of rentable floor space, which makes the maintenance costs less than 7c. per sq.ft. In proportioning the boiler-room costs, including coal, we proportion 80 per cent. to power and 20 per cent. to buildings.

Regardless of these unvarnished figures, which are truly "something awful," we are proud of what we accomplished last year. By "we" I mean my men, who have backed me up so well, our manager, who has done the same, and myself—coöperation which is hard to beat. Surrounded by unfavorable conditions, we have made a determined effort to make the most out of them, and feel that we have done our "bit," as over three-fourths of our power was used for strictly Government essentials, and the balance was utilized for various good purposes.

ARTHUR SUMMERS.

Philadelphia, Penn.

Synchronoscope Operated Sluggishly

Synchronizing indicators are intended to be connected to the circuit only during the period that they are actually in use. If these instruments are left connected to the circuit permanently, there is danger that they will be overheated and injured. In a certain instance a synchronizer had for some time evinced a tendency to act sluggishly. The sluggish action of the instrument apparently did not suggest to the operator that its indications might not be dependable, since it was not until two machines had been connected together while out of phase that the operator awakened to the possibility of an investigation being in order. Testing failed to reveal any open-circuits or other external irregularities, and as the synchronizing lamps continued to be normal in their indications, it appeared that the trouble must be located within the synchronizer itself.

The instrument was removed from the switchboard and partly disassembled, when it was discovered that, owing to overheating, insulating compound had run out of the windings and clogged the air gap between the rotating member and the polepieces, so that the former was practically prevented from turning. However, the winding appeared not to have been injured, and after cleaning the air gap, a trial of the instrument proved its indications to be normal. The heating was found to be caused by the operator leaving the instrument connected to the circuit continuously.

Brooklyn, N. Y. E. C. PARHAM.

A Peculiar Wiring Trouble

Recently, a friend of mine took charge of a power plant that was in a somewhat neglected condition. Among other troubles one of the fuses on one side of a lamp circuit kept blowing frequently. Finally, the circuit was fused with copper wire, and this solved the problem as far as that particular circuit was concerned. Soon after the circuit lighting the boiler room started the same trouble; the fuse blew on one side of it. This circuit was also fused with solid copper, which ended difficulties as far as fuse blowing was concerned.

A signal bell in the engine room had been giving considerable trouble from the contact point on the vibrator burning so badly as to render it inoperative a number of times. A short time after the boiler-room circuit had been fused with copper wire, the same trouble happened to the bell again, and it was also found that the push-buttons were so badly burned as to be useless. New push-buttons were put in, and in a short time the bell and buttons were found to be burned out again.

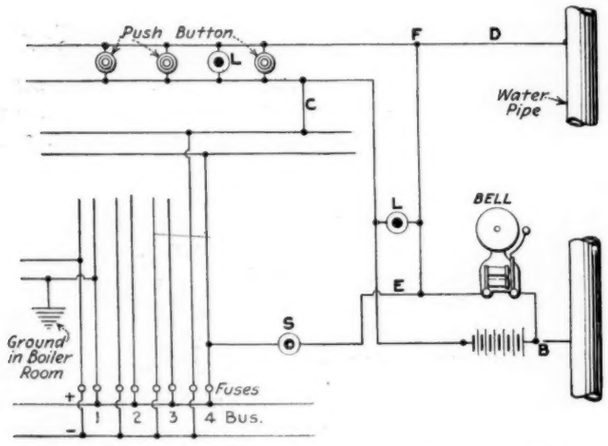


DIAGRAM OF BELL AND LIGHTING CIRCUITS

It is quite evident that the bell wire was in contact with 110-volt lighting circuit at some place. Testing the bell wire failed to locate anything wrong, however. It was therefore decided to arrange a telltale light to indicate whenever the lighting-circuit voltage might be present on the bell. One lamp was connected across the bell circuit close to one of the push-buttons, and another was connected across the bell wire near the bell in the engine room. The sketch illustrates the connections, and *L* and *L* indicate the location of the telltale lamps. The next morning after the lamps were installed they lighted.

To find the circuit on which the trouble originated, the fuses of each circuit were removed and replaced one at a time. When the fuse on the negative side of circuit No. 4 was removed, the light went out. This, by the way, was the side that was fused with copper wire. When the fuse was replaced, the lamps lit again.

When the positive fuse of circuit No. 1 was removed, the lights went out again. This was the boiler-room circuit and did not come anywhere near the bell wire. In tracing out the wires on circuit No. 4 we found that a tap had been taken off one side of the circuit and run between the beams of the ceiling to one side of the bell circuit, indicated at *C*. From this it will be seen that one side of the bell wire was connected to the negative side of a lighting system. Following the bell wire back to the engine room, near the elevator shaft one side of the bell circuit was found connected to a water pipe, as shown at *D*. When this wire was removed, the telltale lights went out.

In the engine room, connected to another water pipe, was found a short wire that had apparently been disconnected from the bell some time before, as the end was hanging near the bell. Another wire was connected to the bell wiring at point *E* and ran along the ceiling through a lamp socket *S* to positive side of circuit No. 4.

Evidently, at some time an attempt had been made to operate the bell on a circuit taken from the lighting system, and to cut down the expense of wire the use of the water pipes had been resorted to. Under the conditions shown, whenever a ground occurred on the positive side of a system, it is plainly evident that there would be full voltage across the bell, as the circuit would be complete from the ground in the boiler room through connection *D* between the point *F* and the water pipe, around to the bell and battery and through *C* to the negative side of the line. This is what burned off the contact point of the bell. After this occurred full lighting-circuit voltage existed across the push-buttons. Closing the push-buttons practically amounted to a short circuit.

The trouble on the boiler-room circuit was due to one of the wires coming loose from the knob on which it had been fastened and swinging down from the ceiling. The plant was provided with a damper regulator, and when the damper was wide open the wire became squeezed between the arm of the regulator and a wooden post. This also explained the intermittent action of the trouble. Unless the damper was wide open, the wire would not be grounded and no trouble would be experienced.

E. W. MILLER.

Minneapolis, Minn.

Ash-Handling Machinery

Herbert E. Birch, in his article on "Buying an Ash Handling System," in your issue of Feb. 5, page 186, mentions the liability to explosion with the pipe conveyor system, as referred to in the Apr. 3, 1917, issue of *Power*. In this connection I would like to call attention to the fact that it will be impossible to have an explosion in the tank connected with a steam-jet system, although the writer knows of several explosions that have occurred where the air system was used.

There seems to be in the construction of the article a thinly veiled effort to discredit the steam-jet system, and I am satisfied that if the author of this article had investigated the latter conclusively, he would not consider the prices advertised in your journal as handling a ton of ashes by this system as "salesmen's hot air." It is generally conceded that conveyors of any class are more efficient than man-power pushing a wheelbarrow or other device. As to the cost of systems, I believe that the specific price of $2200 is rather ill-advised for the reason that I am personally familiar with systems costing considerably less and at the same time have known systems including the bin for the reception of ashes that have cost less.

St. Louis, Mo. ROBERT H. MILLER.

The Boston Turbine Accident

In reading the description of the wrecking of the 35,000-kw. turbine at Boston, in the Mar. 19, 1918, issue of *Power*, the facts and evidence as given suggest an apparently clear and logical process of demolition through which the exhaust end of the turbine may have passed.

The first indication of trouble, according to the article, was when the machine was heard to rub and observed to vibrate, and this came in the nature of a shock. Simultaneously the turbine was heavily overloaded. The operators tried to stop the rubbing, but were unable to do so. These facts can be accounted for by the distortion of the 18th diaphragm, probably in the nozzle vanes, due to increased pressure drop between the 18th and 19th stages, allowing the diaphragm disk to rub the inlet side prongs of the blade forks of the 18th wheel, causing heating in these prongs. When a sufficiently high temperature had been reached, with the consequent reduction of the tensile strength of the blade material, these prongs parted and allowed the blades to foul the nozzle vanes of the 19th diaphragm. This fouling would cause the second shock and commotion. The time required for heating the prongs would be the reason for the time which elapsed between the first and second shocks. The 18th wheel blade débris shows that the inlet side prongs were burned blue and fused, and fractured near the root.

The 18th wheel blades fouling the 19th diaphragm nozzle vanes would partly sever these vanes and allow the 19th diaphragm disk to drop down on the hubs of the 18th and 19th wheels and begin to revolve, completely parting the disk from its ring. The 19th wheel blades would be fouled by the 19th diaphragm nozzle vanes, which, in turn, wouuld foul the nozzle vanes of the 20th diaphragm. The disk of the 20th diaphragm would be parted from its ring and begin revolving in a manner similar to the 19th diaphragm disk. When a sufficiently high speed was attained, the diaphragm disk would burst and begin throwing off pieces. One of the diaphragm disks evidently started disrupting first, and in doing so pieces were probably projected against the diaphragm-supporting cone and deflected toward the generator end. The five pieces that went through the building wall near the generator end of the shaft uphold this supposition. The lapse of time between the second shock and the instant pieces began coming through the turbine casing, when the operating crew were seeking cover, would allow the severed diaphragm disks to reach their bursting speeds.

These diaphragm disk pieces in striking the diaphragm-supporting cone would possibly break it up. The probable weakest section for resisting such blows would be through the 18th diaphragm groove—the supporting cone being held to the shape by the 17th diaphragm and the adjacent external flange. The upper factured piece or pieces of the cone would drop down on the wheels, be whirled around, possibly demolish the exhaust end bearing bracket of the turbine, and finally land among the condenser tubes. The other revolving diaphragm disk probably let go after the supporting cone had been destroyed. The diaphragm pieces that were thrown off radially suggest this action.

Nothing is said of the 18th diaphragm in the description of the accident.[1] It would also be of interest to know to which diaphragm disk the five pieces found near the generator end of the shaft belonged.[2] It would appear that the primary cause of the accident was in the 18th diaphragm, and a secondary cause the absence of a protective rubbing surface on the rim of the 18th wheel, although the 18th, 19th and 20th wheels all have the forked blading.

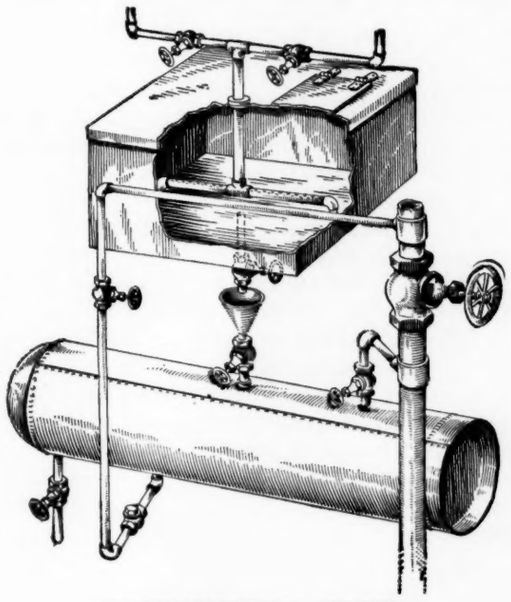
In the comment on the windage test of the last stage wheel of the 25,000-kw. turbine it would appear that the medium in which this test was run was air at atmospheric pressure. Whether the wrecked turbine at Boston was supplied with a vacuum breaker the description does not say, but a vacuum breaker operating in conjunction with the emergency trip throttle valve would be a means of braking a turbine wherein the blade velocities are high, after the generator had been disconnected from its load and before the air pump could be shut down.

C. H. WATSON.

Portland, Ore.

Compound Mixing and Feeding Tank

There are many arrangements of tanks for mixing and feeding boiler compound, but I think I have a better one than any I have seen or read about, therefore I



BOILER-COMPOUND FEEDER

submit it. The illustration will show at a glance its good points. Circulation through the tank is regulated by partly closing the valve in the main-feed line to the boilers. The piping arrangement shown is only intended to convey the general idea and may be modified to suit conditions.

B. DAN DE PASS.

Hudson Heights, N. J.

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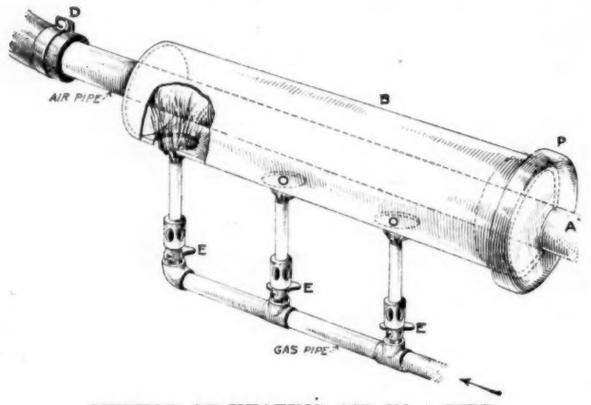
[1] "All wheels and diaphragms up to and including the 17th stage are intact." See paragraph under Fig. 4, page 393, "Power," Mar. 19.

[2] See top of second column, page 392 of "Power," Mar. 19: "When this frame broke it is probable that the 19th and 20th diaphragms let down on the shaft. . . . The significant fact is that these diaphragms are the only large pieces of metal to completely break up and leave the turbine. It was some of these pieces that went through the roof and terra-cotta temporary end wall of the building."

Drying Out Electric Motors

During a high-water period in the Ohio River one part of our plant was submerged, putting many of the motor-driven machines out of commission. We cleaned the machines as quickly as possible, but drying out the motors proved to be a somewhat difficult proposition. After trying several schemes, the method shown in the illustration was devised and used successfully.



METHOD OF HEATING AIR IN A PIPE

Referring to the figure, *A* is a ½-in. pipe leading from a compressed air receiver. A reducing valve was placed in the pipe line before entering the plug *P*. This valve reduced the air pressure down to about 30 lb. per sq.in., which we found more satisfactory than a higher pressure. *B* is a piece of 3-in. iron pipe with openings *O* to allow the gas flames to heat the air in the pipe *A*. Several gas jets may be used, if necessary to work on more than one motor at a time.

A tee-joint may be placed at *D* for branch pipes leading to different motors. The whole heating apparatus can be placed on the floor, and by using flexible-hose branches, the scheme makes a very convenient arrangement.

We left the motors on the floor and blew the air through them, regulating the gas flame so that the air was kept at a temperature that may be called warm. Flexible nozzles covered with asbestos paper were used, as they were found to be better than solid metallic nozzles for getting into the different parts of the motors easily.

G. E. MICHAEL.

Pittsburgh, Penn.

Repair the Liberty Bell

Having become acquainted with the wonderful versatility of the oxyacetylene welding torch, the picture of the Liberty Bell on the cover of *Power*, Mar. 26, suggests, "Why not repair the Liberty Bell and have it ready to ring when the Prussians are beaten and the war comes to an end?" There certainly must be some welder who would undertake the job and who is skillful enough to insure its success. I have welded large gongs and small dinner bells of bronze that resounded just as melodiously as when new, before developing any defect. Welding seems to restore the tone of a bell completely. If the welding is done from the inside of the Liberty Bell, there will be nothing to show that there ever had been a crack.

Think of the old Liberty Bell at the conclusion of the war lifting up its voice again, speaking once more for Liberty in a glad peal resounding from one end of the land to the other. Sentiment might, it is true, be aroused against restoring the voice to the bell, but as well refuse to restore the sight, hearing or voice of some cherished one who had become afflicted, when the surgeon offers a cure. There may perhaps be a reason why welding this bell is impossible. At least it ought to be put up to an expert before the glorious old bell is abandoned to perpetual dumbness.

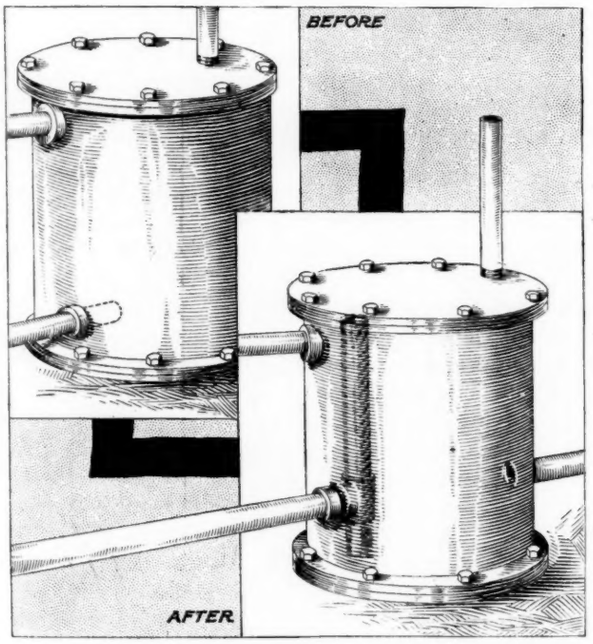
M. MEIGS.

Keokuk, Iowa.

Keeping Oil Out of Feed Pump

We were troubled with oil in our boilers following the time the receiving tank got pumped dry. A repetition of the accidental pumping dry was remedied in a satisfactory and inexpensive way, as shown in the illustration.

The original suction pipe extended straight in, while the new arrangement has a tee on the end of the pump suction pipe, and an open-end standpipe extending above the overflow level, so that when the water level reaches the suction level, air is admitted to the pump through the standpipe and the pump gets no more water, leaving a seal of several inches. The oil is disposed



INSIDE PIPING KEEPS SURFACE OIL FROM PUMP

of through the overflow by allowing the tank to fill and overflow occasionally, so it goes outside instead of into the boilers. This arrangement is cheaper than float valves, etc., and is sure to work.

Oil City, Penn. T. A. MARSHALL.

An Electrical Phenomenon

On page 594, Apr. 23 issue, the discussion letter "An Electrical Phenomenon" should have been signed, Dr. K. Becker, Perth Amboy, N. J.—Editor.

Inquiries of General Interest

Cleaning Water-Leg of Vertical Boiler—How can the water-leg of a vertical fire-tube boiler be thoroughly cleaned? B. W.

Fasten a chain to the end of a wire, having each of sufficient length to pass around the inside of the boiler from one handhole to the next. Then draw the chain into the water-leg and pull it back and forth while washing out the loose dirt with water from a hose.

Negative Exhaust Lap—In a D slide valve what is negative exhaust lap and what is its effect on operation of an engine? T. J. M.

Negative exhaust lap is the amount by which the exhaust edge of the valve fails to cover the port when the valve is in its central position. The effect of negative exhaust lap is to hasten the opening and delay the closing of the ports to the exhaust.

Breakage of Spring of Shaft Governor—What would result if the spring of a shaft governor should break while in use on a high-speed engine? W. F.

The office of the spring is to oppose the action of the centrifugal force on the governor weight in causing shorter cutoff. With the centrifugal force unrestrained, cutoff would take place at the earliest point, the speed would immediately be reduced, and unless the engine were relieved of the load it would slow down or stop.

Indications of Carrying Water Too Low—What are indications that water has been carried too low in a boiler? E. T.

Low water causes tubes to leak at their ends and burning of heating surfaces that have been uncovered by water. Examination of the interior of the boiler will show red coloration of the material at the point where the water has been too low and scale will be cracked off down to the level at which the water was carried.

Parabolic Governor—What is a parabolic governor? F. J. M.

A parabolic governor is one in which the governor balls are constrained to move in the path of a parabola whose principal axis is the vertical axis of rotation. The height of an equivalent pendulum suspension of the balls is constant for all positions, the governor is in equilibrium at but one speed and is said to be isochronous. Such a governor cannot be used successfully on an engine without checking its action with a spring or dashpot, for the slightest increase in speed above the normal causes the balls to rise to their highest position with sudden decrease of speed, alternating with promptly falling and increase of speed.

Movement of Main Bearing on Bedstone—How can movement of the low pressure side main bearing of a cross compound engine on the bedstone be remedied? W. P. S.

If the nuts on the foundation bolts cannot be set down hard enough to hold the stand from slipping, it may be that the bolts are not threaded long enough and washers are required, or that the anchorages are not holding. If the bolts are smaller than the bolt holes in the bedstone, filling the cavities with a thin grouting of neat cement may improve the anchoring or at least hold the bolts steadier. If the anchorages are secure, then with the nuts of all foundation bolts set down hard there should be no movement over the bedstone if the engine is in good alignment.

Testing Accuracy of Vacuum Gage—How is the accuracy of a vacuum gage tested? R. A.

A vacuum gage is generally provided with a dial and pointer for indicating inches of mercury pressure below the pressure of the atmosphere. A gage of this kind usually is tested by connecting it to one end of a U-shaped glass tube of which both legs are about 30 in. long and filled about half their length with mercury. For calibrating the gage one end of the U-tube and the gage are connected to the receiver of an air pump or an ejector operated by steam or water. If the gage is correct, its readings will agree with the number of inches difference in level of the mercury in the legs of the U-tube for different degrees of exhaustion. If a condensing engine is operating when the calibration is to be made, the gage and U-tube may be connected to the condenser and a comparison of the readings will show the errors of the gage for the condenser pressures that are present.

Pump-Piston Speeds and Relative Capacities—What is considered good practical piston speed for reciprocating pumps of various lengths of stroke? Having two pumps of the same diameter and different lengths of stroke, would the pump of longer stroke be considered to have greater capacity? B. F. K.

Good working piston speeds for reciprocating pumps of various strokes are as follows: 3-in. stroke, 40 ft. per min.; 4-in., 50 ft.; 5-in., 60 ft.; 6-in., 65 ft.; 8-in., 75 ft.; 10-in., 80 ft.; 12-in., 90 ft.; 15-in., 100 ft. Many pump manufacturers rate capacities at somewhat higher speeds. A pump with shorter stroke can run with more frequent reversals, but the higher piston speed obtained with longer stroke gives greater capacity for the same diameter.

Effect of Ash on Steaming Value of Coal—Is the value of coal for steaming purposes in proportion to the heat value of the combustible ingredients of the coal? W. L. J.

Ordinarily, the efficiency of combustion decreases with the increase in percentage of ash. The greater the ash content the greater the labor and cost of managing the fire and handling the ashes and the less the efficiency and capacity. When the ash is in excess of 20 per cent. of the dry coal, the commercial value as fuel falls so rapidly with increase of ash that, for use in ordinary furnaces, coals which contain 40 per cent. of ash are comparatively worthless. A high percentage of ash may clinker and clog the fuel bed, thus requiring a higher draft, while the incombustible ingredients form insulating layers that hinder the oxygen of the air supply from coming in contact with the combustible elements of the coal, thus requiring a larger air supply and greater loss from excess air for combustion of the fuel.

Equalizing Cutoff without Indicating Engine—After setting the valves of a Corliss engine, how can the equality of cutoff be tested and corrected without indicating the engine? T. E. H.

Make a mark on the crosshead and a corresponding mark on the guide when the crosshead is at each end of its travel. To test the correctness of cutoff, block up the governor to about the medium height. Then with the wristplate hooked in gear with the eccentric, turn the engine slowly in the direction it is to run, and when the cutoff hook is detached by the cam, stop turning the engine and measure on the guide the distance traveled by the crosshead. Continue turning the engine and note the distance traveled from the other end of the stroke when the steam valve of that end is tripped. If the distance traveled is the same, cutoff will be equal for the particular height to which the governor was blocked and will be approximately equal for other positions of the governor. If the distance is not equal, adjust the length of the governor reach rods until the points of cutoff are alike.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Latent Heat of Vaporization of Ammonia*

By NATHAN S. OSBORNE and MILTON F. VAN DUSEN

The authors, who are physicists with the Bureau of Standards, Washington, D. C., have completed experiments in the determination of the latent heat of vaporization of ammonia, and have compiled a table both in calories per gram and B.t.u's per pound with a range of 40 deg. below zero to 110 deg. above. The ammonia used in the determinations was prepared by Messrs. McKelvy and Taylor of the Chemical Division of the Bureau from commercial anhydrous ammonia manufactured by the synthetic method. A statement of previous determinations is made and these determinations are plotted on a chart accompanying the article.

IN tables of the heat content of ammonia, such as engineers require, the latent heat of vaporization constitutes the major part. Nevertheless the direct measurements of this property are among the rarest of the available experimental data. This is attributable probably to the fact that the latent heat of vaporization may, by thermodynamic formulas, be computed from other properties more easily measurable; however, the data which have heretofore been available for this calculation have not been of a precision such as to yield satisfactory values for the latent heat. The measurements here presented have been carried out in response to the request of the associations of refrigerating engineers of this country for more accurate data upon

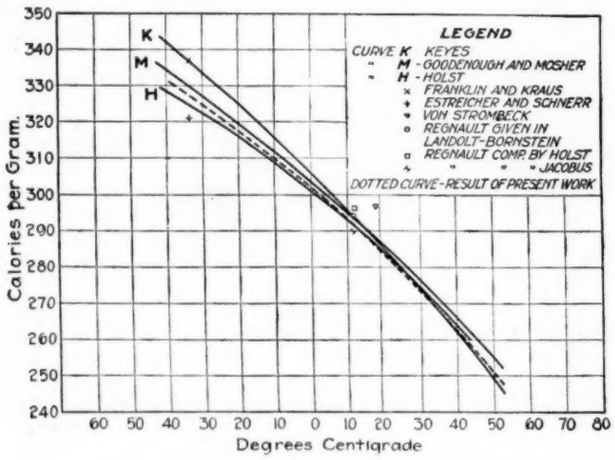


FIG. 1. RESULTS OF PREVIOUS DETERMINATIONS OF LATENT HEAT OF VAPORIZATION OF AMMONIA

which to base calculations for machinery using ammonia in the production of artificial refrigeration.

Results of previous determinations of the latent heat of vaporization of ammonia are represented graphically in Fig. 1. The three curves also shown in this figure represent the values computed from other data by Keyes, Goodenough and Mosher and Holst. Regnault published a record of twelve experiments saved from the ruins of his laboratory destroyed during the Siege of Paris in 1870. The apparatus consisted of two calorimeters—the first, or evaporization, calorimeter in which the ammonia was allowed to evaporate from a steel container and flow through a chamber containing baffle plates, and the second, or expansion, calorimeter in which the ammonia vapor from the first calorimeter was allowed to expand to atmospheric pressure. The capacity of the liquid-ammonia container of the first calorimeter was 246 c.c., but it was filled with various amounts ranging from 17 to 134 grams in different experiments. In each experiment the ammonia was completely evaporated and all vapor expanded to atmospheric pressure. The observed fall in temperature in the water in the first calorimeter varied from 1.7 deg. to 13 deg., and in the second it was usually less than 1 deg. From the data

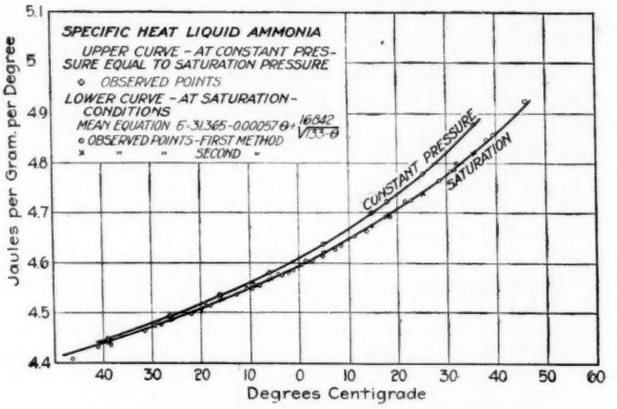

SPECIFIC HEAT LIQUID AMMONIA
UPPER CURVE - AT CONSTANT PRESSURE EQUAL TO SATURATION PRESSURE
○ OBSERVED POINTS
LOWER CURVE - AT SATURATION - CONDITIONS
MEAN EQUATION 5-.31365-0.00057θ+ 16842/(733-θ)
○ OBSERVED POINTS - FIRST METHOD
× " " SECOND "
CONSTANT PRESSURE
SATURATION
Joules per Gram. per Degree
Degrees Centigrade

FIG. 2. SPECIFIC HEAT OF LIQUID AMMONIA

obtained in the first calorimeter Regnault calculated a quantity η_1, which is the heat required to change one gram of saturated liquid ammonia at the initial temperature and pressure to vapor at the mean temperature of the experiment and at a pressure equal to a pressure in the expansion chamber in the first calorimeter.

The calorimeter used in making the experimental determinations given in this bulletin is of the aneroid type

TABLE I. LATENT HEAT OF VAPORIZATION OF AMMONIA

Calories per Gram

Temperature C	0	1	2	3	4	5	6	7	8	9
—40	331.7	332.3	333.0	333.6	334.3	334.9	335.5	336.2	336.8	337.5
—30	324.8	325.5	326.2	326.9	327.6	328.3	329.0	329.7	330.3	331.0
—20	317.6	318.3	319.1	319.8	320.6	321.3	322.0	322.7	323.4	324.1
—10	309.9	310.7	311.5	312.2	313.0	313.8	314.6	315.3	316.1	316.8
— 0	301.8	302.6	303.4	304.3	305.1	305.9	306.7	307.5	308.3	309.1
+ 0	301.8	300.9	300.1	299.2	298.4	297.5	296.6	295.7	294.9	294.0
+10	293.1	292.2	291.3	290.4	289.5	288.6	287.6	286.7	285.7	284.8
+20	283.8	282.8	281.8	280.9	279.9	278.9	277.9	276.9	275.9	274.9
+30	273.9	272.8	271.8	270.7	269.7	268.6	267.5	266.4	265.3	264.2
+40	263.1	262.0	260.8	259.7	258.5	257.4	256.2	255.0	253.8	252.6

B.t.u. per Pound

F										
— 40	597.0	597.7	598.3	599.0	599.6	600.3	600.9	601.6	602.2	602.9
— 30	590.2	590.9	591.6	592.3	592.9	593.6	594.3	595.0	595.6	596.3
— 20	583.3	584.0	584.7	585.4	586.1	586.8	587.5	588.1	588.8	589.5
— 10	576.1	576.8	577.6	578.3	579.0	579.7	580.4	581.1	581.9	582.6
— 0	568.7	569.4	570.2	570.9	571.7	572.4	573.2	573.9	574.6	575.4
+ 0	568.7	567.9	567.2	566.4	565.7	564.9	564.1	563.3	562.6	561.8
+ 10	561.0	560.2	559.5	558.7	557.9	557.1	556.3	555.5	554.7	553.9
+ 20	553.1	552.3	551.5	550.7	549.9	549.1	548.2	547.4	546.6	545.8
+ 30	544.9	544.1	543.3	542.4	541.6	540.7	539.9	539.0	538.2	537.3
+ 40	536.5	535.6	534.7	533.8	533.0	532.1	531.2	530.3	529.5	528.6
+ 50	527.7	526.8	525.9	524.9	524.0	523.1	522.2	521.2	520.3	519.4
+ 60	518.5	517.5	516.6	515.6	514.7	513.7	512.8	511.8	510.9	509.9
+ 70	508.9	508.0	507.0	506.0	505.0	504.1	503.1	502.1	501.1	500.1
+ 80	499.1	498.1	497.0	496.0	495.0	494.0	493.0	491.9	490.9	489.8
+ 90	488.8	487.7	486.7	485.6	484.6	483.5	482.4	481.3	480.2	479.1
+100	478.0	476.9	475.8	474.7	473.6	472.5	471.3	470.2	469.0	467.9
+110	466.7	465.6	464.4	463.3	462.1	460.9	459.7	458.5	457.3	456.1

and was specially designed to meet the requirements of this investigation. At this point the authors go into a thorough description of the calorimeters used, the methods of use employed, the theory of the methods and the experimental details.

The ammonia used in the determinations was prepared by Messrs. McKelvy and Taylor, of the Chemical Division of the Bureau of Standards, by methods to be described in detail in an independent paper. The sample used in the

*Scientific Paper No. 315, Bureau of Standards, Washington, D. C.

determinations of latent heat of evaporation was prepared in May, 1916, from commercial anhydrous ammonia manufactured by the synthetic method. Tests of the purified sample showed about one part in ten thousand by volume of noncondensing gases in the vapor phase and about one part in ten thousand by weight of water.

The latent heat of vaporization of ammonia is given in calories per gram, Centigrade degrees, and B.t.u. per pound, Fahrenheit degrees in Table I. Table II gives the vaporization of ammonia in calories per gram computed by various writers and given in their ammonia tables. The results of the present authors are included for comparison.

TABLE II. HEAT OF VAPORIZATION OF AMMONIA IN CALORIES PER GRAM COMPUTED BY VARIOUS WRITERS AND GIVEN IN THEIR AMMONIA TABLES

The results of the present work are included for comparison

Temperature Deg. F.	Temperature Deg. C.	Ledoux, 1878	Peabody, 1889	Wood, 1889	Zeuner, 1890	Mollier, 1895	Dieterici, 1904	Wobsa, 1908
— 40	— 40	335.2	332	322.0	333.0	332.7	.....	.....
— 22	— 30	330.5	324	316.0	329.9	330.6	.....	324.3
— 4	— 20	325.3	316	309.9	325.8	327.2	.....	317.0
+ 14	— 10	319.7	308	303.8	320.8	322.3	.....	309.0
+ 32	0	313.6	300	297.6	314.9	316.1	309.7	300.4
+ 50	+ 10	307.2	292	291.3	308.0	308.6	298.4	290.9
+ 68	+ 20	300.3	284	284.8	300.1	299.9	285.4	280.6
+ 86	+ 30	293.0	276	278.4	291.3	289.7	272.2	269.4
+104	+ 40	285.3	...	271.9	281.6	278.0	258.3	257.4
+122	+ 50	.....	...	265.3	.....	.....	243.6	244.6
+140	+ 60	.....	...	258.6	.....	.....	227.9	.....
+200	+ 93	.....	...	.....	.....	.....	165.2	.....
+250	+121	.....	...	.....	.....	.....	.....	.....
+270	+132	.....	...	.....	.....	.....	.....	.....

Temperature Deg. F.	Temperature Deg. C.	Hybl, 1911	Macintire, 1911	Lucke, 1912	Mosher, 1913	Holst, 1915	Keyes, 1916	Osborne and Van Dusen, 1917
— 40	— 40	.....	.....	335.3	334.4	328.5	342.0	331.7
— 22	— 30	325.2	327.9	328.1	327.1	322.5	333.6	324.8
— 4	— 20	318.2	320.8	320.9	319.6	316.0	324.9	317.6
+ 14	— 10	310.7	313.0	313.1	311.8	309.0	315.7	309.9
+ 32	0	302.6	304.4	304.6	303.6	301.4	306.0	301.8
+ 50	+ 10	293.7	295.0	294.8	295.0	293.2	296.0	293.1
+ 68	+ 20	284.2	284.7	284.6	285.9	284.4	285.5	283.8
+ 86	+ 30	274.0	273.5	273.5	276.4	274.8	274.4	273.9
+104	+ 40	263.0	.....	261.4	266.2	264.2	262.7	263.1
+122	+ 50	.....	.....	248.3	255.4	.....	250.2	251.4
+140	+ 60	.....	.....	234.7	243.7	.....	236.8	.....
+200	+ 93.3	.....	.....	176.7	195.3	.....	181.9	.....
+250	+121.1	.....	.....	.....	127.6	.....	.....	.....
+270	+132.2	.....	.....	.....	61.2	.....	.....	.....

In Bulletin No. 313 the same authors give the results of experiments in the determination of the specific heat of liquid ammonia. The same type of calorimeter was used as in the determination of the latent heat, and the specific heat of the saturated liquid ammonia has been determined throughout the temperature interval —45 deg. to +45 deg. C. Two distinct and independent methods were used, each of which avoids sources of air present in the other. In the first method the heat added to a fixed amount confined in the calorimeter under saturation conditions and the resulting change in temperature is measured. By using data for the specific volumes of the two phases and the latent heat of vaporization, the corrections for the vapor are applied, giving the specific heat of the liquid when saturated. In the second method the calorimeter is kept full of liquid with a constant pressure. The heat added to the variable amount in the calorimeter and the resulting change in temperatures are measured. A correction for the heat withdrawn and the expelled liquid is determined by special experiments. The greatest difference between the mean results of both methods and the result of either method is represented by an empirical equation which is less than one part in one thousand. In Fig. 2 the results of all determinations by both methods are shown graphically. Fig. 3 shows the present and previous determinations of the specific heat of ammonia.

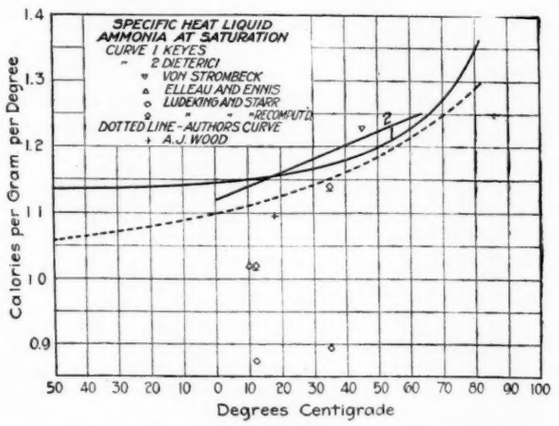


FIG. 3. PREVIOUS AND PRESENT DETERMINATION OF THE SPECIFIC HEAT OF LIQUID AMMONIA

Table III gives the specific heat of liquid ammonia under saturation conditions expressed in calories per gram per degree C. Table IV gives the heat content of the saturated liquid ammonia reckoned from the temperature of melting ice in calories per gram and B.t.u. per pound.

It is interesting to note that the result of 34 separate determinations agree with the mean within one part in one thousand. Both of these papers are now on sale, No. 315 costing 5c. and No. 313 costing 5c.; address the Superintendent of Documents, Washington, D. C.

TABLE III. SPECIFIC HEAT OF LIQUID AMMONIA UNDER SATURATION CONDITIONS

Expressed in Calories per Gram per Deg. C.

Temp., Deg. C.	0	1	2	3	4	5	6	7	8	9
—40	1.062	1.061	1.060	1.059	1.058	1.058	1.057	1.056	1.055	1.055
—30	1.070	1.069	1.068	1.067	1.066	1.065	1.064	1.064	1.063	1.062
—20	1.078	1.077	1.076	1.075	1.074	1.074	1.073	1.072	1.071	1.070
—10	1.088	1.087	1.086	1.085	1.084	1.083	1.082	1.081	1.080	.079
— 0	1.099	1.098	1.097	1.096	1.094	1.093	1.092	1.091	1.090	1.089
+ 0	1.099	1.100	1.101	1.103	1.104	1.105	1.106	1.108	1.109	1.110
+10	1.112	1.113	1.114	1.116	1.117	1.118	1.120	1.122	1.123	1.125
+20	1.126	1.128	1.129	1.131	1.132	1.134	1.136	1.137	1.139	1.141
+30	1.142	1.144	1.146	1.148	1.150	1.152	1.154	1.156	1.158	1.160
+40	1.162	1.164	1.166	1.169	1.171	1.173	1.176	1.178	1.181	1.183

TABLE IV. HEAT CONTENT OF SATURATED LIQUID AMMONIA*

Reckoned from the temperature of melting ice.

Calories per Gram

Temp., Deg. C.	0	1	2	3	4	5	6	7	8	9
—40	—43.3	—44.3	—45.4	—46.4	—47.5	—48.6	—49.6	—50.7	—51.7	—52.8
—30	32.6	33.6	34.7	35.8	36.8	37.9	39.0	40.0	41.1	42.2
—20	21.8	22.9	24.0	25.1	26.2	27.2	28.3	29.3	30.4	31.5
—10	11.0	12.1	13.1	14.2	15.3	16.4	17.5	18.6	19.7	20.8
— 0	0.0	1.0	2.2	3.3	4.4	5.5	6.6	7.7	8.8	9.9
+ 0	+ 0.0	+ 1.1	+ 2.2	+ 3.3	+ 4.4	+ 5.5	+ 6.7	+ 7.8	+ 8.9	+10.0
+10	11.1	12.2	13.4	14.5	15.6	16.7	17.9	19.0	20.1	21.3
+20	22.4	23.5	24.7	25.8	27.0	28.1	29.3	30.4	31.6	32.7
+30	33.9	35.0	36.2	37.4	38.5	39.7	40.8	42.0	43.2	44.4
+40	45.5	46.7	47.9	49.1	50.3	51.5	52.7	53.8	55.0	56.2

B.t.u. per Pound

Temp. Deg. F.	0	1	2	3	4	5	6	7	8	9
— 40	—77.9	—78.9	—80.0	—81.1	—82.1	—83.2	—84.3	—85.3	—86.4	—87.4
— 30	67.2	68.3	69.4	70.4	71.5	72.6	73.6	74.7	75.8	76.8
— 20	56.5	57.6	58.7	59.8	60.8	61.9	63.0	64.0	65.1	66.2
— 10	45.8	46.9	48.0	49.0	50.1	51.2	52.3	53.3	54.4	55.5
— 0	35.0	36.1	37.2	38.2	39.3	40.4	41.5	42.6	43.6	44.7
+ 0	35.0	33.9	32.8	31.7	30.7	29.6	28.5	27.4	26.3	25.2
+ 10	24.1	23.0	21.9	20.9	19.8	18.7	17.6	16.5	15.4	14.3
+ 20	13.2	12.1	11.0	9.9	8.8	7.7	6.6	5.5	4.4	3.3
+ 30	— 2.2	— 1.1	0.0	+ 1.1	+ 2.2	+ 3.3	+ 4.4	+ 5.5	+ 6.7	+ 7.8
+ 40	+ 8.9	+10.0	+11.1	12.2	13.3	14.4	15.6	16.7	17.8	18.9
+ 50	20.0	21.1	22.3	23.4	24.5	25.6	26.8	27.9	29.0	30.1
+ 60	31.3	32.4	33.5	34.7	35.8	36.9	38.1	39.2	40.3	41.5
+ 70	42.6	43.8	44.9	46.0	47.2	48.3	49.5	50.6	51.8	52.9
+ 80	54.1	55.2	56.4	57.5	58.7	59.8	61.0	62.1	63.3	64.4
+ 90	65.6	66.8	67.9	69.1	70.3	71.4	72.6	73.8	74.9	76.1
+100	77.3	78.5	79.6	80.8	82.0	83.2	84.3	85.5	86.7	87.9
+110	89.1	90.3	91.5	92.6	93.9	95.1	96.3	97.5	98.7	99.9

*Heat content as used here is defined by the relation: $H = e + pv$

Where H = heat content, taken as zero at the temperature of melting ice, e = internal or "intrinsic" energy, and H, e, and pv are all expressed in the same units.

In Scientific Paper No. 314 the same authors give the results of experiments in the determination of the latent heat of pressure variation of liquid ammonia for a temperature range of —40 to +40 deg. C. This paper may be obtained free by addressing the Director, Bureau of Standards, Washington, D. C.

The War-Savings Stamp plan is a means of directing the nickels, dimes and quarters of the ordinary man into the United States Treasury for safe-keeping so that at the end of the war the poor man may find himself no less poor, if not richer, than he was at the beginning. It means "postponed" prosperity, and thus from the business point of view is a most desirable asset.

Manning the New Merchant Marine

By HENRY HOWARD
Director of Recruiting Service, U. S. Shipping Board

The Director of the Recruiting Service, United States Shipping Board, tells of how America is meeting the problem of manning her great merchant fleets. The Recruiting Service is responsible for providing the whole human side of the ships built for the Shipping Board. Qualifications required of applicants to engineering schools; names and addresses of the section chiefs to whom applications should be made.

PRESENT construction plans for our merchant marine call for more than 8,000,000 tons of new shipping, to be completed within two years. At the beginning of the world war, in August, 1914, seven nations were credited with more than 1,000,000 tons of shipping each. Great Britain headed the list, with 19,799,119 tons; the United States stood next, with 7,928,688 tons, and Germany third, with 4,892,416 tons. The other nations stood: France, 2,173,544; Norway, 2,425,476; Sweden, 1,114,048, and Japan, 1,167,264. Austria had 998,130 tons. Of the tonnage of the United States something more than 2,000,000 tons was available for deep-water service in the Atlantic.

The first year of the war was sufficient to show the United States that the process of attrition in the world's supply of tonnage, due to normal war causes and to the illegal use of the submarine by Germany, was creating a shortage of ships. This shortage became acute when the United States entered the war in April, 1917, thereby adding to the already pressing problem of logistics this country's vast needs of sea transportation for troops and supplies and the quickened need of sending more and yet more supplies to our Allies.

Coincident with the sudden awakening of the nation to the vital need for more cargo ships and the energetic initial steps of the Shipping Board to produce them came forward the question of manning the new merchant marine so soon to come into being. The country as a whole not having been accustomed, in recent times, to think in terms of shipping, appeared doubtful of its ability to produce the mariners needed to handle its new fleets. We were no longer a seagoing people, said the doubtful; we had lost the art of the sailor when the American square-rigged ship went out of use as a leader among the world's cargo carriers. Surely, our war need was pressing enough to appeal to the patriotism of Americans with a liking for the sea.

By establishing free schools in navigation at important ports and free classes in marine engineering at some of the leading technical colleges, I proposed to train enough men of the types indicated to meet the forthcoming increased demand for American deck and engine-room officers for the new American cargo ships.

On May 29, 1917, I was authorized by the Shipping Board to inaugurate the training plan, and on June 1 was sworn in as Director of Recruiting Service for the board. Three days later the first free navigation school to be conducted under the direction of the United States Shipping Board was opened, with 20 students, at the Student's Astronomical Laboratory, Harvard University, kindly loaned by the college faculty. Later, this school was transferred to the Massachusetts Institute of Technology, where it has since been maintained.

The work of organizing additional schools went on until 41 in all were established on the Atlantic, Gulf and Pacific Coasts and the Great Lakes. The response of men qualified to enter the schools was quick and gratifying as to numbers and, nothwithstanding that no man was accepted as a student who had not served two years on a deep-water vessel, the percentage of men who qualified for admission, out of the total number of applicants called for preliminary examination, was large. Many of the applicants, actuated by patriotism, expressed a willingness to leave lucrative positions ashore in order to fit themselves for service in the merchant marine in war time. Others frankly hailed with delight an opportunity to get back to the sea, which they had left because of unpromising conditions in the decade preceding the opening of the great war.

National headquarters of the new training service were established at Boston, where a floor in the Boston Custom House was set apart for its use by the Treasury Department. For administrative purposes in establishing and maintaining the schools the country was divided into sections, following closely the geographical divisions employed by the United States Steamboat Inspection Service, which from the first coöperated heartily with the Recruiting Service of the Shipping Board in maintaining the standard set by the regulations of the Department of Commerce as to the experience required of a candidate for a merchant officer's license.

Each section was placed in charge of an official designated as section chief, in whose hands were placed all details as to the administration of the schools in that section. The board was fortunate in securing as section chiefs men of professional or business training, whose patriotism led them to donate their time to this service, their compensation being merely nominal—in most instances $5 a month. Important positions at national headquarters also were filled by volunteers with special capacity for administrative work.

The section chiefs of the service are as follows: Section I, Horatio Hathaway, Jr., twelfth floor, Custom House, Boston, Mass.; Section II, John F. Lewis, 108 South Fourth St., Philadelphia, Penn.; Section III, Hardy Croom, 130 Riverside Ave., Jacksonville, Fla.; Section IV, Ernest Lee Jahncke, 814 Howard Ave., New Orleans, La.; Section V, Farnham P. Griffiths, 465 California St., San Francisco, Calif.; Section VI, William J. Crambs, 860 Stuart Building, Seattle, Wash.; Section VII, Capt. Irving L. Evans, 933 Guardian Building, Cleveland, Ohio.

System of Instruction

Direction of instruction in the navigation schools was placed in the hands of Prof. Alfred E. Burton, dean of the Massachusetts Institute of Technology, who formerly was connected with the Coast and Geodetic Survey and who is a practical navigator of wide scientific knowledge.

The system of instruction perfected for the schools was in accordance with the most approved methods of teaching navigation. It was therefore possible to impart to a student in six weeks' study a groundwork of the theory and practice of navigation to enable him to pass the examinations of the United States Steamboat Inspection Service, entitling him to a license as a second or third mate. The examinations were conducted without any modification of the regulations applying to ordinary applicants for a license. After they had been passed, the student in need of practical experience on a steamer was sent to sea in the capacity of a reserve officer, for a period of two months to learn the ropes before actually assuming the full responsibilities of the position for which he was licensed. During this period he was paid $75 a month. Afterward he received the usual pay for his grade in the merchant service.

Since the opening of the first school in navigation by the Recruiting Service of the Shipping Board, 39 others have been opened. The graduates from these schools, in the ten months from June 1 to Apr. 1, numbered 1500.

Engineering Schools

The development of the engineering schools was contemporaneous with that of the schools in navigation. The training of engineers was placed in the hands of Prof. Edward F. Miller, of the Massachusetts Institute of Technology, and classes were established at the following places:

Massachusetts Institute of Technology, Cambridge, Mass.; Stevens Institute of Technology, Hoboken, N. J.; Bourse Building, Philadelphia, Penn.; Johns Hopkins University, Baltimore, Md.; Tulane University of Louisiana, New Orleans, La.; Case Schools of Applied Science, Cleveland, Ohio; Armour Institute of Technology, Chicago, Ill.; University of Washington, Seattle, Wash. The school at Hoboken was later discontinued, and one was started at the Seamen's Church Institute in New York City.

The course in the engineering schools is of one month's duration. The qualifications for admission to these schools differ slightly from those required for admission to the navigation schools, as men with proper technical experience are admitted who may require as much as six months added training at sea before becoming eligible for licenses.

Experience required for an applicant to qualify for admission to enter one of these Shipping Board Engineering Schools is classified as follows: Three years as fireman, on ocean or coastwise steam vessel; two years as oiler or water tender (or combined service of two years in these positions); six months as chief or assistant engineer, on lake, bay or sound steamer; one year, chief or assistant, river steamer; one year as locomotive or stationary engineer (with six months' sea service, which may be obtained after finishing school course); graduation from engineering class of nautical schoolship; graduation in mechanical engineering from a technical school (with six months' sea service); one year in charge of stationary plant of not less than 1000 hp.; three years as apprentice to machinists' trade (with six months' sea service).

About 1200 marine engineers were graduated from the Shipping Board free engineering schools in the first ten months of their existence. Like the dock officers graduated, all were American citizens.

One noticeable effect of the Recruiting Service's call for Americans qualified to serve as officers in the new merchant marine was the stimulation given men qualified to take examinations for licenses, without special schooling. Large numbers of such men, excellent mariners and citizens, secured licenses on their own initiative, without attending the Shipping Board schools, as is shown by the unprecedented number of licenses granted from June 1, 1917, to Feb. 1, 1918, by the Steamboat Inspection Service. Not less than 3600 original licenses were issued in that period—including those issued to the men specially trained by this service—while not less than 900 licenses were extended or transferred from fresh waters to salt; while to Apr. 1, 1918, the number of new and extended licenses was more than 5000.

The Sea Service Bureau

As a necessary adjunct to its training service for officers, the Recruiting Service in July, 1917, established a department whose functions are indicated by its title, the Sea Service Bureau.

Graduates of the schools were placed on board ship by this department, at first entirely through the coöperation of private steamship interests, and later also on ships controlled directly by the Shipping Board.

Training Merchant Crews

By the autumn of 1917 the construction program of the United States Shipping Board, by which considerably more than 1000 new ships will be commissioned under our flag, had advanced sufficiently to warrant the development of the second phase of the training plan originally submitted to the board for manning the new merchant marine; namely, the training of crews.

Much thought was given by the Recruiting Service staff to working out a system of intensive training for crews, by the use of a squadron of training ships. In December the Shipping Board approved the resulting detailed plans, and on Dec. 12, 1917, announcement was made in the press that the Recruiting Service was prepared to receive applications from young Americans between 21 and 30 who wished to be trained for service on merchant ships as sailors, firemen, coal passers, oilers, water tenders, cooks and stewards. In the three months following this announcement more than 7500 applicants sent their names to the Recruiting Service headquarters, Custom House, Boston, Mass.

The number of men required for this branch of the training service was at first estimated to be 85,000; but events subsequently led to a modification of this figure. The transportation of an immense American army to France, and of its supplies, called for the taking of a great many ships from the merchant marine. The need of arming all ships entering European waters with naval guns led to a proposal that all ships crossing the submarine zone be manned by the Navy. After several conferences on this point between officials of the Navy Department, the War Department—then operating the troop ships—and the Shipping Board, a decision was reached by which control of troop ships, animal transports and freighters carrying unbroken cargoes of munitions and supplies for military uses were placed in control of the Navy, to be manned by Naval crews, while Atlantic passenger liners, freighters with general cargoes for our Allies and all merchantmen plying outside the war zone were left in the control of the Shipping Board.

Work in training the new crews was begun the day the board's authority was granted me to proceed with the plan. To administer the training service, a department was created, termed the Sea Training Bureau, with a supervisor of training in charge.

For the training squadron two steel screw steamers were at once secured, the "Calvin Austin" and "Governor Dingley," twin ships, formerly in the passenger trade on the New England coast, each being of 3800 tons gross register, 299 ft. long and 60 ft. wide, with reciprocating engines and 2700 i.hp. Each vessel had a rated capacity for 783 passengers. Being speedily converted into training ships, the vessels each had capacity from 500 to 600 apprentices. Because of the large number of applicants it was possible to select superior material for their complements, which filled rapidly in the first weeks of 1918..

While these two ships were being filled, a third was being fitted out at Newport News. This was the former transport "Meade," ex-"City of Berlin," a graceful old Atlantic liner, with a sound hull and capacity for more than 1200 apprentices. It was planned to take this ship also to Boston, to be used as a station ship, while the other two made frequent training trips to sea. Later, a fourth ship, the "Governor Cobb," of the type of the two first-named, was put into the training squadron, and plans were put on foot for placing a training ship on the Pacific Coast and another at New Orleans.

The training course is of an intensive character. There is an instructor to each ten apprentices, and he is held responsible for the progress of his group. The apprentices virtually go to school all day, and every day except Sunday, during their stay on the ship, which is not less than a month in any case, and will probably exceed two months in few.

When the apprentices have finished their intensive training, they are added to regular crews in the merchant marine, on a given ratio to the experienced men carried. By this method it is expected that no difficulty will be experienced in securing full crews for all ships added to the merchant fleet by the Shipping Board, as well as for any existing ships that may need men.

In perfecting a plan for enrolling apprentices for its training ships, the Recruiting Service availed itself of the offer of a patriotic citizen of Boston, Louis K. Liggett, head of large interests in the drug trade, controlling nearly 6900 drug stores in 6393 cities and towns.

The young men accepted for training by the Shipping Board Recruiting Service are placed on pay at $30 a month for their period of training and are exempt from military service as long as they remain in the merchant marine, either as apprentices or as members of regular crews.

[Those applying for service as engineers aboard ships of the United States Shipping Board or for training at the various engineer schools of the board should address their applications to the headquarters of the section chiefs nearest their homes, or to United States Shipping Board, Recruiting Service, Custom House, Boston. This does not apply to the Navy or the Naval Reserve.—Editor.]

Centrifugal Pumps for Mine Service*

The experience of many years with a large variety of pumps forms the basis of this article. Although the theory of the centrifugal pump as usually set forth by writers on this subject is somewhat complicated, the machine itself is simple. Its successful installation and operation require only care and judgment.

FOR anyone wishing to study the theory of centrifugal pumps, there are three or four books in the English language devoted to the subject upon which he can devote as much energy as he desires. There are a few rules, however, that it is well to remember; namely, for equal efficiencies the power required to drive the pump varies as the cube of the speed, the head as the square of the speed, and the capacity directly as the speed. The head in feet that any impeller will work against is approximately the diameter of the impeller in inches times the revolutions per minute divided by 1950 squared, or $H = \left(\frac{d \times r.p.m.}{1950}\right)^2$.

The most distinctive part of the whole machine is the impeller, the function of which is to take the slowly moving water in the suction pipe and, by revolving create by centrifugal force a velocity head in the water convertible into a pressure of sufficient intensity to overcome the static and friction heads of the discharge pipe. The impeller is mounted on a shaft carried by bearings, and is inclosed in a casing. The shaft is connected to the driving element. This is, in a general way, all there is to a centrifugal pump.

The casing should be so designed as to be readily opened, giving access to the entire inside of the pump. This is most readily accomplished by employing the so-called horizontally split casing that has the suction and discharge openings on the bottom half which is bolted to the baseplate. Such an arrangement permits the top half of the casing to be removed without breaking any pipe joints or disturbing the alignment of the pump—considerations that are of great importance when repairs have to be made in a hurry.

Vertical Split Superior to Horizontal

The horizontal split is not so good mechanically and structurally as the so-called "vertical split," in which the annular portion of the casing is in one piece and the internal parts are withdrawn from the end, after removing the end plate which usually forms the suction pump-head. But this procedure necessitates the breaking of the suction-pipe joint. Furthermore, the parts must be pulled out one at a time—first the impeller, then the diffusion ring, next that part of the casing forming the return guide for the water to the second impeller, then the second impeller and so on—a long, tedious job, especially in large units.

In putting the parts together, the reverse order must be followed and care must be taken to insure that all the parts come to place properly, in order to prevent them from overlapping and partly closing the water passages in the casing. In such cases reliance must be placed entirely upon careful measurements; and it is very hard to make men to whom a foot more or less is good enough understand the importance of measuring to $\frac{1}{16}$ or $\frac{1}{32}$ in. or less. With the horizontal split, as before stated, after lifting the top half off the machine all internal parts are in view and can be removed readily. Furthermore, before the top half of the casing is replaced one can *see*—not feel—that everything is as it should be.

The ends of the casing through which the shaft projects are provided with stuffing-boxes and glands. The stuffing-boxes should be deep enough to take not less than four or five rings of good soft packing. The glands, preferably made in halves, should fit tight in the box but be about $\frac{1}{16}$ in. larger than the shaft. To the back of the stuffing-box renewable rings should be fitted, so that if they become worn and allow the packing to be squeezed into the pump, they can be replaced. The stuffing-box on the suction side, particularly when the pump is working under a suction lift, should be provided with a water seal to prevent air being drawn into the pump and also to lubricate the packing with water.

Removable rings should be provided around those parts of the casing in which the impeller or other moving parts revolve, so that in case of wear—which is bound to occur even under the best conditions and quite rapidly when pumping acidulous mine water—these rings can be replaced.

One of the chief causes of loss in efficiency of centrifugal pumps is internal leakage between a stationary and a revolving element, prevented only by a close running fit. There are several types of labyrinth rings used, the idea being that the water has to traverse a narrow, tortuous passage which it can follow only with difficulty. These rings may have merit when good, clear water is pumped, but for mine use a plain straight ring is preferable. This should have a width of ¾ to 2 in., with a running clearance of 0.006 to 0.01 in., depending upon the size of the impeller and, except for the larger sizes when fresh water is used, should be of bronze.

In modern pumps the impellers are of the inclosed type, with the blades or vanes curving backward, making an angle of from 12 to 24 deg. with the outer diameter.

Thin Blades Corrode Quickly

Originally pump builders thought that the impeller blades should be as thin as possible, with the tops cut to a knife-edge, but this was found to be a fallacy, especially in bad water, for the thin blades corroded quickly and the knife-edges doubled over and closed the port openings. The impeller walls and blade should be $\frac{1}{8}$ in. thick for 12-in. diameter impellers and $\frac{5}{8}$ in. thick for 24-in. and larger impellers. With such impellers higher initial efficiency, far better average efficiency and much longer life are obtained than with thinner blades. Impellers should be provided with renewable wearing rings where they fit into the casing. These rings can be shrunk on, and all rotating elements should be balanced.

Some builders claim that diffusion vanes are essential to obtain high efficiency with multistage pumps. Others assert that they can get just as high efficiency without them. Diffusion vanes, which are stationary plates with guide vanes curved in an opposite direction to the impeller blades, are arranged to encircle the impeller and receive the water discharged from the impeller tips at high velocity, and by reducing its speed convert velocity head into pressure head. The usefulness of diffusion vanes is not always apparent, since by actual tests of different makes of two-stage pumps, under about the same operating conditions (one with and one without diffusion vanes) their efficiencies were found to be practically the same. If diffusion rings are used, they should be of bronze; and provision should be made to prevent their turning in the casing and to prevent leakage around the vanes.

The pump shaft should be of steel protected by cast-bronze sleeves or bushings placed over all parts of the shaft that come in contact with the water. The end bushings should project through the stuffing-boxes and form the nuts that keep the impeller in place laterally. Provision should also be made to prevent leakage along the axis of the pump shaft, which can be done by inserting fiber gaskets $\frac{1}{8}$ in. thick between the impeller hubs and the ends of the bushings.

Impellers should fit snugly on the pump shaft, but need not necessarily be a driving fit, and they should be secured from turning by bronze (not steel) feather keys. The pump shaft, when hung in its bearings, should be large enough in diameter to support the weight of the impellers and the column of water without perceptible deflection, so that the internal sealing rings and bushings will not be

*Abstract of an article by Herbert Axford, pump inspector, Coal Department, Delaware, Lackawanna & Western R.R., Scranton, Penn., in *Coal Age*.

required to support any weight. In many instances the undue wear of sealing rings has been directly due to the pump shaft deflecting under load.

Bearings should be of the ring-oiled type with renewable liners in halves. Bearing boxes should be provided with bolted caps, so that the bearing liners may be renewed or rebabbitted without removing the shaft; and so that when the top half of the casing is removed together with the bearing caps, the complete rotating element can be lifted from the pump.

One of the most important details in a centrifugal pump is the thrust bearing. Unbalanced end thrust causes a great deal of trouble to the operator and it is oftentimes difficult to locate and remedy the defect. Theoretically, every pump leaving the factory is hydraulically balanced. The double suction impeller has inlets of the same diameter on each side and the impellers thus having the same pressure on each side are perfectly balanced—on paper. But let one side get choked or one side take more water than the other, or the leakage through the sealing rings on one side be more than on the other, then an unbalanced condition is immediately established.

This unbalanced pressure has to be carried by the thrust bearing. There is also the single-suction impeller, wherein the water enters on one side only. This is balanced by putting a duplicate set of sealing rings back of the impeller. Holes drilled in the rear wall of the impeller connect with the inner chamber formed by the sealing rings and thus balance the pressure in this chamber with that of the suction. Sometimes some of these holes have to be plugged or enlarged in order to equalize the end thrust.

There is also the "back-to-back" type of impeller, where the suction on one impeller or one set of impellers is on the left-hand, while the suction of the other (or the other set) is on the right-hand side. This arrangement should form a perfect end balance, and yet the thrust bearing may get red hot after a few minutes' run.

Large Marine-Type Thrust Bearings Satisfactory

The most satisfactory bearing for all ordinary purposes is the marine thrust type—that is, a series of steel collars running between babbitted collars, plentifully supplied with oil. Such a bearing is preferably run in a bath of oil with the thrust box water-cooled to keep the lubricant at normal temperature. Furthermore, this thrust bearing should be made large.

Several companies are building pumps in which hydraulic balance is effected by water leaking from the discharge side of the impeller into a balancing chamber and then out past a balancing disk, which rotates with the pump shaft, into the suction side of the pump. This device works automatically and gives satisfactory service where the water is clear and free from grit and acid, but it soon becomes useless when pumping acidulous or gritty water.

The couplings which connect the pump and motor shafts should not be any heavier than necessary, and should be of the pin-and-buffer type to allow a certain amount of end play without putting stress on the thrust bearing of the pump.

The baseplate should be of cast iron, heavy enough to resist distortion if the pump be subjected to careless handling during erection, or if the foundation settles a little.

Although some of the points mentioned may seem trivial and others self-evident, they must all be watched carefully. If the front or inner bearing of some pumps should burn out—an occurrence by no means uncommon—it would be necessary, in order to replace the bearing, to move the whole pump from its base, break the suction and discharge connections and remove the coupling from the shaft. If the men who designed such pumps were compelled to repair them in a mine while the water was rising over their shoetops at the rate of an inch a minute, there would soon be a radical reform in the design.

Another matter for investigation is the use of small screws, dowels or pins on the inside of the pump. Some builders—in fact the majority—can think of only a small screw or dowel to prevent a ring or bushing from turning, but acidulous mine water eats these small parts out so quickly that they are useless, and when they give way they seem to have the habit of lodging between some stationary and rotating element, thereby cutting grooves and ridges and almost ruining the machine.

The best speed to drive centrifugal pumps is a much-debated question. Just now builders of pumps and motors seem to be advocating high rotative speeds to secure efficiency, but for mine use moderate speed is preferable wherever possible, as less trouble is then experienced with both pump and motor. Elsewhere the higher-speed pumps apparently give good service. For 75 or 100 hp. and upward 900 r.p.m. is satisfactory; for 30 to 50 or 75 hp. 1200 r.p.m., and for smaller pumps 1500 to 1800 revolutions per minute.

The head per stage is another open question; but, in general, pumps working under 100 ft. per stage have a longer life than those working over 100 ft. per stage. Consequently, until further evidence is produced, it seems best to keep close to 100 ft. per stage as the maximum.

The centrifugal is about the simplest pump to operate when a few conditions are complied with. For example, means must be provided for priming or filling the machine with water. Where the pump is placed below the source of water supply, it is primed as soon as the valve in the suction pipe is opened and all entrained air is allowed to escape from the casing; but when the pump is placed above the water supply, some provision must be made for filling it, somewhat as follows:

Where pumps are to work under heads of less than 400 ft., a foot valve is placed on the suction pipe near to, and preferably submerged in, the water (not necessarily at the deepest or lowest point of the suction pipe, where it would be hard to reach in case of any trouble) and water is admitted into the discharge pipe at a point sufficiently above the pump to completely fill the pump casing. This method is usually adopted around mines, since when the pump is shut down a valve in the discharge pipe is closed.

The tail pipe, an important part of the installation, must be air-tight and laid so as to prevent the formation of air pockets; it must also be of sufficient diameter to avoid excessive friction. No attention should be paid to the size of the suction opening on the pump, for it will usually be found that such openings are one or two sizes too small except for short suction lines and light suction lifts. To start a motor-driven pump it is necessary only to prime it and start the motor.

Don'ts for Pump Runners

The following don'ts for pump runners cover all ordinary operating points:

Do not run a pump without water.

The numerous bushings and sealing rings on the inside of a pump depend on water for lubrication, and if the pump is run without being first filled with water these parts will get hot and "freeze," doing great damage to the pump.

Do not run without oil in all the bearings.

Do not run with dirty oil in the bearings.

Do not let water get into the bearings.

Before starting up, see that the bearings are full of clean engine oil and that there is no water in the boxes. This can be done by loosening the drain plug on the bottom of the box to see if clean oil comes out and by measuring the depth of oil in the box. Do not rely altogether on the oil-level gage, as this sometimes gets choked up. To keep the bearings clean, drain all oil out of the boxes once a week and thoroughly wash out with two or three bucketfuls of water. The old oil should be filtered and used over again if it is not too gummy.

Do not run the stuffing-box glands tight.

This produces unnecessary friction, causing the boxes to heat up and the packing to burn out. Having the glands loose and allowing them to leak a little keeps the packing lubricated and the stuffing-boxes cool.

Do not run with leaky joints around pump.

This is unnecessary, and if not stopped in time will ruin the joint faces.

Do not allow water to collect around the motor.

Keep the baseplate of the pump clean, for when the motor is running the air suction produced draws the dirt and moisture into the motor.

Do not run a pump or motor that vibrates excessively.

This is caused by the machines not being in balance or line. It should be reported at once.

Do not run unless you are satisfied that all parts are in good condition.

Do not allow oil, grease or dirt to accumulate anywhere in the pumproom.

If properly cared for, a centrifugal pump will run with little trouble.

The advantages of centrifugal pumps are briefly as follows: Small floor space is required, therefore they can be installed in a small pumproom. The machine is light in weight, therefore it is easily handled in close places and requires no expensive foundation; in fact it can be set on skids. It can be quickly installed and can be direct-connected to an electric motor, dispensing with noisy and troublesome reduction gearing. It has no valves or plunger packing, therefore will have no packing or valve troubles. It gives a steady flow of water without shocks, can be started with the column line full, and furthermore, cannot do itself or pipe lines harm should the line become blocked or if someone forgets to open the valve on the discharge line before starting. Last, but by no means least, it is a reliable pump, with a minimum cost of maintenance, except possibly where the water is extremely acidulous or gritty.

Pumps Should Be Accurately Aligned with Motors

Centrifugal pumps should be set on a fairly good base and accurately lined with their motors. Although pumps are usually coupled to their motors by so-called "flexible" couplings, these are not flexible in the sense that they are a sort of universal joint. They simply permit end motion, and although they permit operation with the pump and motor slightly out of line, trouble will eventually follow. Piping should be connected to the pump squarely and accurately, for it is possible to strain and distort the pump casing if force is used to bring the piping and pump connections in line. As stated previously, provision should be made for priming the pump. Check valves should be installed in the column pipe with a bypass around so as to drain the line. When the capacity has to be regulated by throttling, a gate valve must also be installed in the discharge pipe line; in fact, when the water is not highly acidulous, it is wise to install both a gate and check valve in all column pipes. But where the water is extremely acid, it has been found that the gate valves wear out quickly and that good leather-faced check valves last so much longer that the gate valve is omitted and reliance is placed entirely on the check valve.

The strainer on the end of the suction pipe should have the mesh, or size, of the holes so small that nothing will pass through which is likely to lodge in and block the impeller. The total area of the holes should be two or three times that of the suction pipe. There should be no less than four feet of water over the strainer, for it is possible to draw air bubbles down through even four feet of water, especially if the velocity is high. Provision should be made for water-cooled bearings, water seals on the suction glands, and the air vents should be piped properly. With the larger machines, provision should be made for handling the heavy parts—that is, for taking off the top half of casings, and removing the shaft and impellers by means of a hand crane or chain hoist. If these few common-sense directions are followed and good water is pumped, the machine will run satisfactorily for years. If the water is acidulous it is necessary merely to change the sealing rings; on the quality of the water the frequency of such renewals depends. If gritty the grit gets in between the fast-moving internal parts and acts like a grindstone, cutting the normal working clearance of $\frac{1}{100}$ in. to ⅛ or ¼ in. in a very few days.

The maintenance of pumps is a simple matter as the parts most subject to wear are the shaft bearings, the shaft sleeves in the stuffing-boxes, the sealing rings on the impellers, together with the distance and stage bushings in multistage pumps. These last-mentioned parts generally wear rapidly, and it is an excellent plan to keep an extra pump rotor on hand—that is, a shaft with impellers, rings and shaft sleeves—also an extra set of bearing liners. Then, when the pump declines in capacity (which is a general sign that the sealing rings are worn, allowing too much internal leakage or short-circuiting of the water) it is an easy matter to open the machine, remove the old rotor, put in the new one and bring the pump back to its original capacity and efficiency. The old rotor is then sent to the shop to be rebushed and held in readiness for further use.

If this is done before the pump gets too badly worn, the operation can be repeated many times and the cost of repairs reduced, but the repairing must be done in a careful and painstaking manner or the repair costs and troubles will more than double.

A restricted suction will cut down the capacity of the pump and give excessive end thrust. A leaky suction pipe will also cut down the capacity and give an unsteady and fluctuating pressure and flow and produce excessive vibration and noise in the pump.

If the holes in the strainer are so large that chips of wood, coal and other substances enter the pump and block the impeller vanes, trouble ensues.

Thrust-bearing troubles can be greatly reduced if large thrust bearings provided with an efficient oiling system are used. When abnormal thrust occurs, as before mentioned, examine the suction line first; then if the trouble is not located, open the pump and see if one set of sealing rings is worn more than another.

Efficiency of Centrifugal Pumps Low

Centrifugal pumps are not recommended as a rule for capacities of less than 300 gal. per min., and even for this capacity the head should not exceed 60 ft. For heads of 100 to 150 ft. 500 gal. per min. is considered the minimum, but for capacities of 1000 gal. per min. it can be used for almost any head with fairly good efficiency. Two 1500-gal. eight-stage pumps working against a total head of 820 ft. have been in successful operation for two years, giving a pump efficiency of about 68 per cent. The efficiency of the centrifugal pump is generally low. A 300-gal. pump gives about 50 per cent., a 500-gal. pump about 55 per cent. and larger pumps give anywhere from 55 to 72 per cent. efficiency. This latter efficiency is the highest of which the writer has actual knowledge, and that was secured from a machine of large capacity working under a moderate head.

Each centrifugal pump must be built for a certain capacity and head at a given speed, and it is herein that the maximum efficiency lies, because the capacity and head cannot vary materially from these fixed conditions without a considerable loss in efficiency. This means that a centrifugal pump built for a certain head and driven by a constant-speed motor cannot be used for any other head, much greater or less, without sacrificing efficiency, and the capacity when driven at a constant speed cannot be changed or varied except by the uneconomical method of throttling. These points should always be taken into consideration.

The steam-turbine-driven centrifugal boiler-feed pump has been well received, but is not recommended for boiler plants of less than 3000 rated horsepower, since small ones are unusually run at such high speed that it does not take much to put them out of order. Furthermore, the first cost, steam consumption and upkeep will be high. For plants of 8000 hp. or over, they are superior to the plunger pump, but between 3000 and 8000 hp. the selection hinges largely upon local conditions and individual preference.

The Latent Heat of Steam

The latent heat of steam at standard pressure and temperature is a fundamental constant, the value of which has long been less satisfactorily known than was desirable. The values given in Kaye and Laly's "Physical and Chemical Constants" differ appreciably, ranging from the 537 calories of Regnault obtained in 1847 to the 540 calories found by Joly in 1895. In Callendar's steam tables the value 539.3 is adopted. A new determination is described in a paper by T. Carlton-Sutton, published in a recent issue of the *Proceedings* of the Royal Society. The plan of the experiments consisted in weighing the quantity of steam condensed upon a bulb, both when empty and when filled with water. From the two observations the latent heat can be deduced, the value found being 538.88 mean calories. It is claimed that this figure is correct to the fourth significant figure.—*Engineering.*

Some Fundamental Considerations of Power-Factor Correction*

By R. A. McCARTY
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What the power factor of an alternating-current circuit is and its effects upon the capacity of generating and transmitting equipment are discussed, and the use of synchronous machines as a means of correcting the power factor is considered.

THE power factor of an alternating-current circuit may be defined as the ratio of the actual energy in kilowatts to the apparent energy in kilovolt-amperes, expressed in percentage. For example, if the kilowatt load on a circuit is 1000 and the kilovolt-ampere load 1250, then the power factor of the circuit is 1000 ÷ 1250 = 0.80, or 80 per cent. This relation between actual and apparent energy is dependent on the relative "phase" position, with respect to time, of the current and voltage of the circuit, which in turn is fixed by the characteristics of the circuit and the connected apparatus, as will be mentioned later.

In any alternating-current circuit if both the voltage and current pass through corresponding instantaneous values, that is, pass through zero and maximum points, simultaneously, they are said to be "in phase." When this condition exists, the actual and apparent energies are equal and the power factor is 100 per cent. If, however, the voltage passes through any given instantaneous value before or after the current passes through the corresponding value, the two are "out of phase." When this condition exists, the true energy is less than the apparent energy and the power factor is something less than 100 per cent. If curve *A*, Fig. 1, represents voltage and curve *B* the current in phase with the voltage, then curve *D* will represent a current out of phase with the voltage.

The latter condition is the immediate result of the reactive, or wattless, current present in the circuit. In any alternating-current circuit having a power factor less than 100 per cent., the current that flows is made up of two parts, the energy component in phase with the voltage and the reactive component, which leads or lags behind the voltage 90 electrical degrees. These two components of the current, therefore, bear a 90-deg. relation to each other and combine geometrically to give a resultant current that lags or leads the voltage by an angle less than 90 degrees.

Again referring to Fig. 1, if curve *A* represents the voltage and curve *B* the energy component of the current, then curve *C* will represent the reactive component and curve *D* the current that results from the combination of *B* and *C*. Assuming a direction of phase rotation from right to left, the current represented by curve *D* lags behind the voltage *A*.

The reactive current in any circuit is due to inherent characteristics of certain apparatus such as induction motors, transformers, reactance coils, arc lamps, etc., which make them draw from the source of supply, not only the work current which transmits the useful energy but reactive-magnetizing current as well. Since the reactive current not only transmits no useful energy but has the detrimental effect of causing increased losses, which appear in the form of heat, in the transmission line, transformers and generating apparatus, thereby reducing their useful capacity, it is obviously desirable to reduce to a minimum or neutralize the effect of such current. The very marked increased heating, for a given rating, or the reduction in rating, of the generating apparatus, which results from low-power-factor loads will be mentioned later.

*A paper presented before the Iron and Steel Electrical Engineers and the Pittsburgh Section of the American Institute of Electrical Engineers at Pittsburgh, January 12, 1918.

In practically all commercial circuits the demand for lagging reactive current predominates to such an extent that it is seldom if ever necessary to consider the case of leading current in connection with power-factor correction alone. For that reason all further reference will, unless otherwise stated, presuppose a condition of lagging power factor.

There is at the present time but one commercially successful type of apparatus for general application of neutralizing the effects of lagging reactive current. This apparatus consists of overexcited synchronous motors used either to deliver part of their capacity in mechanical load and the remainder in corrective effect, or their full capacity as corrective kilovolt-amperes. Under the latter condition they are usually termed synchronous condensers.

Any synchronous motor, when operated with a field excitation just sufficient to set up the flux required to generate a counter-electromotive force which equals the impressed electromotive force minus the ohmic and reactance voltage drops in the armature winding, will draw from the line a current in phase with the voltage, therefore operates at 100 per cent. power factor. Other things remaining constant, if this field adjustment is varied the motor will in addition to taking the energy current required, draw from the supply a reactive current which either opposes or assists the current in the motor's field winding in maintaining the flux required for the counter-electromotive force. With the motor's field underexcited, the reactive current drawn from the line is a magnetizing current, in the same sense as that drawn by an induction motor; that is, it lags behind the line voltage, thereby tending to still further reduce

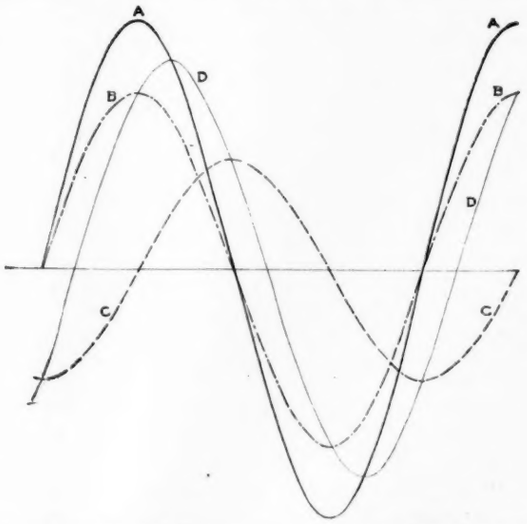


FIG. 1. CURVES SHOWING RELATION BETWEEN AN ALTERNATING CURRENT AND VOLTAGE

the power factor of the total system. For this reason it is very important that the field excitation of a synchronous motor should always be adjusted to its proper value. If, however, the field is overexcited the reactive current drawn from the line is a demagnetizing current and leads the line voltage. Therefore it is possible to neutralize the effect of any lagging reactive current by introducing into the system a like amount of leading current. As previously indicated, the required leading reactive current may be introduced into the system by using a synchronous motor of the proper capacity, operating with an overexcited field.

The questions of proper corrective capacity, its location in the system, whether it shall be in one or more units and

whether the machines shall deliver both mechanical energy and corrective effect or only the latter, have, of course, to be determined for each particular case. The detail conditions which ordinarily determine the decisions in regard to these points are beyond the scope of this discussion, but one or two principal factors may be mentioned. There are several accurate but more or less involved methods for determining the required corrective capacity for any given case, but all this becomes unnecessary and the problem

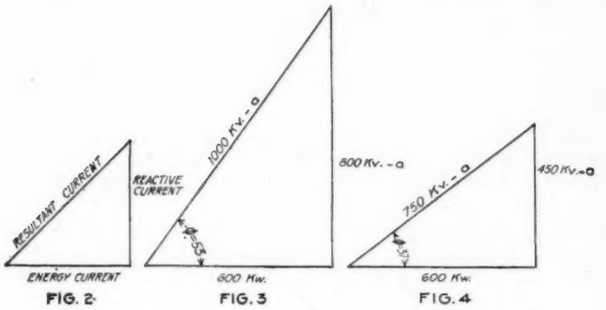


FIG. 2. FIG. 3. FIG. 4.

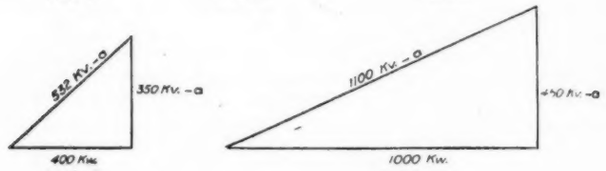


FIG. 5. FIG. 6.

FIGS. 2 TO 6. SHOW THE RELATION BETWEEN ENERGY, REACTIVE AND RESULTANT CURRENTS

extremely simple if we keep in mind the fundamental principles; namely, that the leading and lagging reactive currents are in opposition, hence the resultant reactive current is the algebraic difference; that the reactive current is 90 deg. out of phase with the energy current; that the resultant current is the geometrical sum of these two; and that the power factor of the system is the ratio of the kilowatt to the kilovolt-amperes.

Expressed geometrically, the energy current, reactive current and resultant current form a right-angle triangle, Fig. 2, in which the base represents the energy current, the vertical line the reactive current and the hypotenuse the resultant current, as indicated. Since, if the currents in the system bear these relations to each other, the kilowatt, reactive kilovolt-amperes and resultant kilovolt-amperes must bear the same relations, we will for convenience use the same triangle to indicate the latter quantities.

Assume, then, a system having a load of 1000 kilovolt-amperes at a power factor of 60 per cent. and it is required to find the corrective kilovolt-amperes to raise the power factor to 80 per cent., and the resultant total kilovolt-amperes of the system. To determine the lagging reactive kilovolt-amperes of the system, refer to the triangle, Fig. 3, the hypotenuse or total kilovolt-amperes is 1000, the base or energy is 60 per cent. of this value or 600 kw. and the vertical side or reactive kilovolt-amperes is found, by solving the triangle, to be 800 kilovolt-amperes. Repeating this construction for the system with a power factor of 80 per cent., the kilowatt will of course remain constant at 600, Fig. 4. Since the power factor can be expressed as the cosine of the angle between the resultant kilovolt-amperes, and the kilowatts, or in this case equals 0.80, the angle between the resultant kilovolt-amperes and kilowatts will be that having a cosine corresponding to 0.80. or approximately 37 deg. Then drawing the hypotenuse at an angle of 37 deg. to the kilowatt line and completing the right triangle, it will be found that the resultant total kilovolt-amperes will be 750 and the reactive kilovolt-amperes 450. Obviously, then, the required corrective kilovolt-amperes to produce this result is the difference between 800 and 450 or 350 kilovolt-amperes. If this corrective kilovolt-amperes is obtained by a synchronous condenser, its rating will be 350 kilovolt-amperes. If this corrective effect is to be obtained from a machine that is to deliver mechanical energy as well as the corrective effect, the rating of this machine is found as follows:

Assume that the motor is to deliver 500 hp. and at the same time supply 350 kilovolt-amperes corrective effect; determine the capacity of the motor and the final total kilovolt-amperes of the system. Allowing for the efficiency of the motor, it would have a kilowatt input of 400. Combining this as before at right angles, with the 350 kilovolt-amperes (Fig. 5) the corrective kilovolt-amperes rating of the motor is found to be 532. The total kilovolt-amperes of the system then becomes the resultant of 1000 kw. (sum of original 600 kw. and additional motor 400 kw.) and the uncompensated reactive kilovolt-amperes of 450. These, combined as before at right angles, give a total system kilovolt-amperes of approximately 1100, Fig. 6. It should then be noted that the addition of the 400 kw. energy load, in addition to the 350 kilovolt-amperes corrective capacity has resulted in raising the power factor of the total system to $1000 \div 1100 = 0.91$, or 91 per cent.

The location in the system of the machine delivering the corrective effect should, to obtain the greatest gain, be at or near the source of the lagging reactive current. Otherwise the reactive currents have to be transmitted over the intervening lines, and through transformer, switches, etc., causing additional losses.

The question of using synchronous condensers or partly mechanically loaded motor for this service largely depends on the questions of capacity required and the relative locations of the demands for mechanical energy and corrective effect. In general, if the two are combined, the first cost of the required apparatus is less and the cost of buildings and maintenance is less.

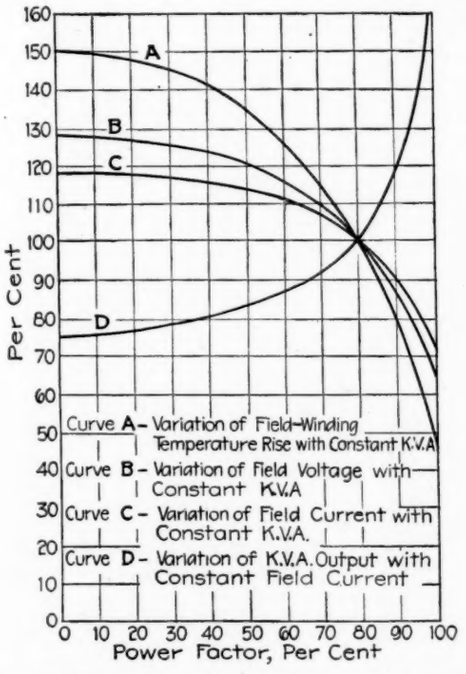

Per Cent
Power Factor, Per Cent
A
B
C
D
Curve A - Variation of Field-Winding Temperature Rise with Constant K.V.A
Curve B - Variation of Field Voltage with Constant K.V.A
Curve C - Variation of Field Current with Constant K.V.A.
Curve D - Variation of K.V.A. Output with Constant Field Current

FIG. 7. SHOWS VARIATION IN ALTERNATOR PERFORMANCE WITH CHANGE IN POWER FACTOR

To show this point in a concrete way, the relative cost of a motor-generator set consisting of a 1000-kw. 250-volt direct-current generator driven by a 2200-volt three-phase 14-pole 60-cycle 80 per cent. power-factor synchronous motor was compared to the cost of a set of the same capacity except driven by a 100 per cent. power-factor motor with a separate 8-pole synchronous condenser having the same corrective capacity as the 80 per cent. power-factor motor (approximately 850 kv.-a.). This comparison showed that the 80 per cent. power-factor motor set has a first cost of 90 per cent. of the other machines and only 80 per cent. of the losses. A notable installation of this kind is now building for the Tennessee Coal, Iron and

Railway Co., consisting of five 750-kw. direct-current generators driven by 1500-kv.-a. motors. These motors, in addition to driving the generators, supply approximately 1200 kv.-a. each in corrective capacity.

The question is sometimes raised regarding the use of synchronous converters for power-factor correction. Machines of this class as normally designed are not adapted for this service, by reason of the limits from heating both in the armature and field windings. Owing to the difficulties of obtaining satisfactory commutation under load conditions with the flux distribution that results from the presence of the reactive current in the armature, designing machines with sufficient heating capacity for this service is looked upon with disfavor.

To emphasize the desirability, particularly from the standpoint of the generator, of maintaining system power factors, at, say, 80 per cent. or higher, the curves, Fig. 7, have been worked up for a normally designed generator rated at 6000 kv.-a. at 500 r.p.m., showing the variations in performances with varying power factors. These curves show, basing all performances on 80 per cent. power factor as the normal condition and assuming constant kilovolt-ampere output, that if the power factor drops to 60 per cent., the exciting amperes become 111 per cent., the exciting voltage 116 per cent., and the field temperatures rise 126 per cent. of those quantities at 80 per cent. power factor. On the basis of reducing the output to maintain the same field heating, a change from 80 per cent. power factor to 60 per cent. reduced the generator rating to 86 per cent. of the original output.

Special Joint Committee Hearing on Administration Water-Power Bill

THE Special Joint Water-Power Committee of the House of Representatives held another hearing on the Administration bill on Apr. 15, with Sir Adam Beck, chairman of the Hydro-Electric Power Commission of Ontario, as the speaker. Sir Adam delivered an exhaustive analysis from his own point of view of conditions relating to water-power development in the Dominion, and the sale of hydro-electric energy in Ontario, as compared with what he knows of conditions in the United States. He made a strong plea for monopoly in public utilities and presented figures tending to show that under government control in Toronto the rate for electricity is about half the rate at Buffalo, and made other comparisons between rates in the United States and in Ontario.

Secretaries Baker and Houston To Be Heard

The hearings before the joint committee will not be closed until the committee has heard Secretary Baker of the War Department, Secretary Houston of the Agricultural Department, and any members of Congress who desire to be heard. The framing of the final bill will therefore be delayed in the committee.

Sir Adam Beck has been identified with water-power matters in Ontario "since 1903 or 1905." He traced the growth of legislation in Canada, saying franchises were originally granted to generate power at Niagara Falls on the Canadian side, as follows: To the Canadian-Niagara Power Co., 100,000 hp.; to the Electric Development Co., 125,000 hp., and to the Ontario Power Co., 180,000 hp. He said the object of the boards of trade, merchants' associations, etc., in Ontario was to make this power available generally to the people of the district, and because of the great advance in the art of transmitting energy at high voltage, economically, to great distances, a desire was created in manufacturing districts to have this power available for them. Sir Adam pointed out that Ontario has no known coal fields at this time, and that one of the power difficulties there is the necessity for long transportation, and a duty on coal. That difficulty has long continued.

In 1902, he said, various civic bodies appointed a committee to confer with the legislature on steps to enable municipalities to undertake the generation of electricity. The legislature had two years previously refused the city of Toronto a franchise to develop power, and instead had granted such a franchise to the Electric Development Co., which had affiliated with it the Toronto Electric Light Co. and the Toronto Street Railway Company.

Finally, the legislature passed an act allowing municipalities to borrow money on their own account for power and light development, and a commission was appointed to investigate, which, after eighteen months' work, practically said that power could be delivered at cost; but the practical difficulty of raising money was encountered, and further rights for development were granted to the Electric Development Company.

Sir Adam then told of changes in the government following elections and of the passage of the present acts and amendments. He said:

We have power to acquire by purchase or otherwise, on any terms, and hold shares in any incorporated company carrying on the business of developing, supplying and transmitting electrical energy. We have power to appropriate the land, waters, water privileges or water powers or works, machinery and plants or portions thereof of any person owning or operating under lease or otherwise or operating or using water-power privileges or transmitting electrical power or energy in Ontario which in the opinion of the commission should be purchased, acquired, leased, taken, expropriated and developed or used by the commission for the purposes of the act. Now, that is pretty drastic, but it is all subject to arbitration.

At the present time the Ontario Commission has contracts with 225 municipalities. They pay all interest charges at 4 per cent. and a sinking fund of 1.8 per cent., which retires in thirty years. They pay all charges of depreciation, operation, administration, etc. The chairman continued:

We operate at the present time twelve systems. They will become interconnecting eventually and form one great trunk system. In this way we are attaining the object of the whole scheme; namely, that there should be one control only. . . . We want to create a real monopoly because we believe all these service undertakings should be a monopoly. There is little satisfaction in having competition in a telephone system, or a telegraph system, or even a railway system, and certainly not in an electric system in any community. The obnoxious poles and wires, the great dual cost of everything, and the great dual investment that results because of the diversity created by these various corporations covering the same field are undesirable from every standpoint.

The Power Situation at Niagara

As to the Niagara situation, Sir Adam said the principle laid down by the International Waterways Commission is that there should be an equal division of water for power purposes on all international streams, and pointed out that there is now pending an application that the United States Government shall confer with the Dominion authorities regarding a proposal to allot another 10,000 ft. per sec. to each government. This, he pointed out, is advanced as a war measure, and will be justified even though the most efficient use is not made of the water. Sir Adam said he believes that if this measure is carried through it will not be canceled after the war and will stimulate production after peace comes. He presented figures to show that the total power now being generated on both sides of Niagara is 653,500 hp. Of this amount 265,000 hp. is generated in the United States, which also receives 110,000 hp. exported from the Canadian side, making a total of 375,000 hp. available in the United States. This amounts to 40 per cent. more for the United States than for Canada, although the latter country generates 100,000 hp. more than the United States.

There is no intention on the part of either the Canadian government or the commission to interfere with the present export arrangement, even though Canada is now short 100,000 hp. In order to permit a continuance of the export, Canada has arranged to do away with all sign lighting, window lighting and other uses of energy which in some quarters have been characterized as less essential. The power generated by the province of Ontario has reduced coal consumption between 5,000,000 and 6,000,000 tons per annum. Motive power has been saved, use of cars has been saved, and duty on coal has been saved. The esti-

mated potential horsepower of hydro-electric energy in Canada is about 50,000,000, and in Ontario alone about 5,000,000 or 6,000,000, with but 700,000 developed. At the beginning of the commission's work, in 1910, only 750 hp. was being delivered to the twelve municipalities interested. The commission has acquired up to date about 86 corporations, through friendly negotiations, and without resorting to the drastic powers given to it under the act.

Coal-Car Situation Serious

The United States Fuel Administration is gravely concerned over the serious falling off in coal production which has become apparent since the beginning of the coal year on Apr. 1. Despite the many measures adopted by the Fuel Administration to increase production and facilitate distribution, the supply of bituminous coal of the country fell off 1,500,000 tons, or 14 per cent., during the week ended Apr. 6, as compared with the preceding week, according to the reports of the Geological Survey.

Some part of this loss was due to failure of mine labor on Apr. 1, Mitchel Day, the anniversary of the enactment of the eight-hour law. With the exception of two weeks during the hardest weather of the winter, the daily bituminous production was lowered during the week ending Apr. 6 more than at any time since the Fuel Administration was organized.

A large part of this falling off in production, however, is due to the continued lack of transportation service as evidenced by the shortage of cars placed at the mine to be loaded. This is due to the general pressure of war traffic on the railroads. Car shortage reports for the week ended Apr. 6 are not yet available, but for the week ended Mar. 30 the mines throughout the country showed an average loss in production due to car shortage of 23.3 per cent.

In the fields of Illinois, Indiana and Ohio the average loss due to car shortage was 22.6 per cent. In one of these, the northern and central Ohio field, the loss was 34.2 per cent. In the Pennsylvania fields the loss in production due to car shortage averaged 32.4 per cent. In the New River and Winding Gulf and Pocahontas fields, which supply the low-volatile coal vitally needed by the Navy and the merchant marine for bunker purposes, loss in production due to car shortage was 24.4 per cent. In the high-volatile fields of southern West Virginia and the Fairmont, the average loss in production due to car shortage was 50.3 per cent.; the southern high-volatile fields lost 41.6 per cent. and the Fairmont fields 59.1 per cent. Cumberland Piedmont field showed a loss of production of 15.6 per cent., and the mine fields in Kentucky, the Southern Appalachian fields and the southwestern Virginia fields an average loss of 29.7 per cent., due to car shortage.

On the other hand, in the Alabama, Kansas, Missouri, Oklahoma, Arkansas, Iowa, Rocky Mountain and Pacific Coast fields the car service was within 5 per cent. of normal. Except for Alabama the bulk of the output of these mines goes into domestic consumption and is utilized west of the Mississippi River. It does not enter into the transportation problem in the congested Eastern territory.

This continued shortage of cars at the mines in the fields supplying the Eastern industrial territory has had the effect of keeping mine labor idle for days at a time, and in some of the fields has cut the working time to one or two days a week. Under these conditions the mine workers, unable to maintain themselves and their families on their curtailed pay, have been tempted by the steady employment offered by the war industries in the manufacturing centers.

The Fuel Administration is gravely apprehensive lest this condition result in the complete demoralization of the labor supply of the bituminous mining industry. Even a short continuance of these car-supply conditions will result in the forcing out of the mining fields the labor which the mining operators and the Fuel Administration may find it impossible to replace, even if the railroads are unable to offer a full car supply to the mines later in the summer. Reports to the Fuel Administration give evidence of unrest and dissatisfaction among the mine workers who throughout the past year have given patriotic service, even when it meant a personal sacrifice.

Among the causes of disturbance curtailing production is the unsettled situation regarding contracts for railroad fuel. This question is under consideration by the Railroad and Fuel Administrators and will be settled at the earliest moment possible.

The Fuel Administration is convinced that unless there is immediate and material improvement in car supply efficiency, the country faces the certainty of a serious shortage of bituminous coal.

The Fuel Administration will undertake to see that the preferred classes included in Preference List No. 1, of the Priority Committee of the War Industries Board are the first to receive their quota of the limited supply. This priorities list includes domestic consumers of coal.

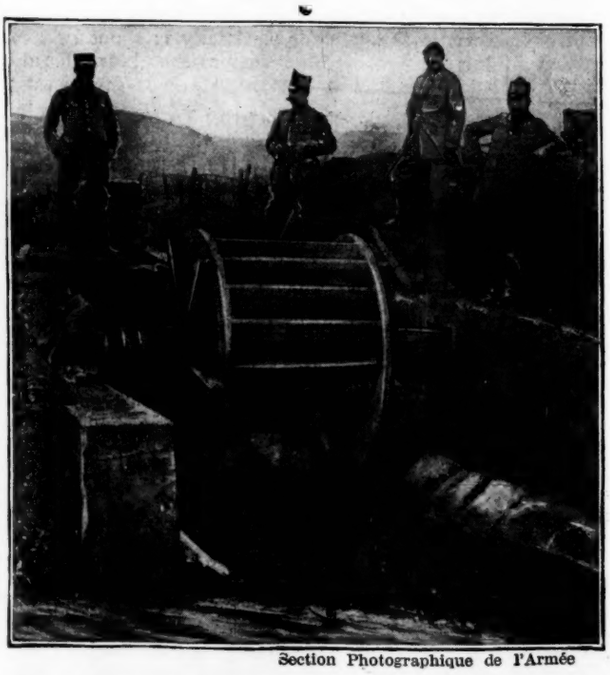
Patriotic coöperation by the domestic users of the country in the effort of the Fuel Administration to secure the "early ordering" of next winter's domestic coal supply has filled up many of the retail dealers of the country with orders that cannot be delivered for weeks or possibly months. These consumers will be given their proper preference, however, and their coal will be delivered just as rapidly as the railroads can move it. The uncertain state of the supply makes it imperative that every domestic consumer should have his order in the hands of his dealer at the earliest possible moment.

National and State Conventions

American Order of Steam Engineers	Philadelphia	June	11–13
Canadian Assn. of Stationary Engineers	London	June	25–27
Universal Craftsmen Council of Engineers	Cleveland	Aug.	12–17
National Association of Stationary Engineers	Cincinnati	Sept.	9–14
Int. Union of Steam & Operating Engineers	Cleveland	Sept.	9–14

N. A. S. E. STATE ASSOCIATIONS

California	San Diego	June	14–16
Illinois	Ottawa	June	5– 7
Indiana	Indianapolis	June	26–28
Iowa	Cedar Rapids	June	12–14
Kansas	Topeka	May	1– 3
Kentucky			
Michigan	Flint	July	10–12
Minneapolis	Duluth	Aug.	14–16
Missouri			
New England States	Bridgeport, Conn.	July	10–12
New Jersey	Perth Amboy	June	1– 2
New York	Brooklyn	June	14–16
Ohio	Cincinnati	Sept.	8– 9
Pennsylvania	Chester	June	20–21
Texas	Dallas		
West Virginia			
Wisconsin	Appleton	July	18–20



Section Photographique de l'Armée

This photograph, received from *Power's* correspondent in France, shows an improvised waterwheel for generating current to light the dugouts of a French battery.

New Publications

GRAPHICS. By H. W. Spangler. Published by John Wiley & Sons, New York City. Cloth, 6 x 9¼ in., 95 pages. Price, $1.25.

The book contains the substance of lectures on the subject of graphics given to the students in mechanical, electrical and chemical engineering at the University of Pennsylvania. They are intended to cover only fundamental principles, and those familiar with the subject will recognize that the methods of treatment used by the many writers have been utilized in their preparation. Many of the short-cuts in common use are not referred to in the text as the time allotted to this work is limited, and while such short-cuts are of special value in special work, they are readily grasped by one who has a fundamental knowledge of the entire subject.

The author states that it is intended that the book shall be used as a reference work. It should serve this purpose well.

REFRIGERATION By Milton W. Arrowood. Published by the American Technical Society, Chicago. Flexible leather, 7 x 4¾ in., 272 pages exclusive of the index.

This little book has the appearance of a handbook, but cannot be said to be a handbook of the usual type as the author has endeavored to treat the subject more from a practical than from a theoretical viewpoint, giving only enough physical theory on the problems of heat measurements, pressure, etc., to make the text understandable. On the whole the illustrations in the book, which are mostly line drawings, are well done. Good descriptions of the various systems of refrigeration are given, and the descriptions of commercial machines are very good. In that part of the book treating of ice making the author deals with the various systems, with storing and selling ice and with ice-plant insulation. About 38 to 40 pages are devoted to cold storage. Pages 143 to 160 are devoted to methods of refrigeration, proportions between the parts of a refrigerating plant, testing, operation and management of the plant.

COAL: THE RESOURCE AND ITS FULL UTILIZATION

The Division of Mineral Technology, United States National Museum (Smithsonian Institution), is producing a set of papers entitled "The Mineral Industries of the United States, six in all, the aim being to present a constructive analysis of the fuel situation in the United States. This series is known as Bulletin 102, Parts 1 to 6 inclusive. Those already issued are: Part 1, Coal Products: An Object Lesson in Resource Administration. Part 2, Fertilizers: An Interpretation of the Situation in the United States. Part 3, Sulphur: An Example of Industrial Independence. Part 4 (just out). Coal: The Resource and Its Full Utilization. Part 5 (in preparation). Power: Its Significance and Needs. Part 6 (in preparation). Petroleum: A Resource Interpretation.

Part 4, just to hand, is a splendid, dispassionate analysis of the fuel situation, pointing out in nontechnical language the things that are necessary and must ultimately be done to correct the inherent deficiencies in the utilization of coal. In spite of ample supplies in the ground, coal inadequately meets its obligations: first, because of the competitive manner in which it is mined; second, the unnecessary extent to which it is transported; and, third, the improper way in which it is used. The Bulletin contains 26 pages, 6 by 9 in., and is worthy of careful reading.

Personals

O. S. Maple, formerly purchasing assistant of the United States Shipping Board, Emergency Fleet Corporation at Washington, D. C., has recently been appointed assistant purchasing officer of that corporation.

W. Nelson Smith, who was for some years electric traction engineer with Westinghouse Church Kerr & Co., and more recently efficiency engineer of the American Agricultural Chemical Co., is at present with Sydney E. Junkins & Co., engineers and constructors, of Vancouver, B. C.

Charles Philip Coleman, who has been vice-president of the Worthington Pump and Machinery Corporation since May, 1916, and prior to that was receiver of the International Steam Pump Co. and associate companies, which have since been reorganized into the present corporation, has been elected president.

J. C. Rockwell has been promoted from manager of the light and power department to general manager of the Manila (P. I.) Electric Railroad and Light Co. He joined the operating organization of the J. G. White Management Corporation, New York City, in 1911, and was assigned to the Manila Electric Railroad and Light Co. as manager of the light and power department. He has been on a visit to the United States and is now returning to Manila.

Engineering Affairs

Plant Engineers' Club—The entertainment committee made a trip to Providence on Wednesday, Apr. 24, to visit the Narragansett Electric Light Co., and to inspect the new 50,000-kw. generator set and the new Leblanc condenser. In the evening, at the Boston City Club, they discussed the question of proper fire and police protection in large manufacturing plants.

The New York Chapter of the American Association of Engineers concluded its first year's activity with a dinner and speeches at the Grand Hotel on the evening of Apr. 20. The speakers were R. H. Vanderbrook, retiring chairman of the chapter; S. J. Stone, chairman-elect; I. L. Birner, secretary; William Serton, H. H. Bubor, W. J. Ash, C. H. Nordell, A. C. Davis and J. F. Jones.

The Combined Associations of Greater New York N. A. S. E., through the New York State Educational Committee announce a lecture by Mr. Forde, of the Westinghouse company, on the evening of May 4, on "Steam Turbines and Auxiliary Apparatus," at Ionic Hall, Terrace Garden, 155 E. 58th St., New York City. Through the courtesy of Charles S. Bavier a visit will be made to the power plant of the Metropolitan Insurance Co. Building, Madison Ave. and 23rd St., New York, on the evening of May 2.

Boston Engineers' Dinner—The ninth annual dinner of the Boston Society of Civil Engineers, American Society of Mechanical Engineers and the American Institute of Electrical Engineers will be held at the Boston City Club, Tuesday, Apr. 30, 6:15 p.m. James W. Rollins will be toastmaster. So far, two speakers have been engaged. W. H. Blood, Jr., of the American International Shipbuilding Corporation, will speak on "The Greatest Shipyard in the World"; Alfred D. Flynn, secretary of the Engineering Council, will speak on "The Engineering Council. Its Progress and Changes." Other speakers likely will follow. The presidents of the societies represented, also representatives of the Army and Navy, have been invited as guests.

Miscellaneous News

Thrift-Stamp Day Advanced to Monday, May 6—It has been decided to advance Thrift-Stamp Day in the United States from May 1 to May 6, in order to avoid conflicting with the wind-up of the Liberty Loan drive, which ends May 4. So remember your new slogan is "Sixth of May, Thrift-Stamp Day in the U. S. A." This gives you more time to put it over bigger and better than ever. Keep hustling.

Business Items

The Johns-Pratt Co., of Hartford, Conn., has appointed Lucas Blanco & Co., as its agents for Porto Rico, Virgin Islands, Dominican Republic and the Republic of Haiti.

Trade Catalogs

Centrifugal Pumps—The Wheeler Condenser and Engineering Co., Carteret, N. J. Bulletin 108-B. Pp. 8 x 10½ in. Shows the latest Wheeler turbine-driven geared centrifugal pumps, for either series or parallel operation; and special slow-speed engine-driven pumps.

NEW CONSTRUCTION

Proposed Work

Mass., Canton—The Springdale Finishing Co. will build a 1 story, 50x50 ft. engine house on Pine St., Springdale. A. H. Wright, 53 State St., Boston, Arch. Noted Apr. 16.

N. Y., Buffalo—The Donner Steel Co., 475 Abbott Rd., has had plans prepared for the erection of a 2 story, brick and steel boiler shop, locker, etc. Estimated cost, $20,614.

N. Y., Elmira—The Elmira Water, Light and Power Co. has been authorized by the Public Service Commission to build an electric transmission line from here to Montour Falls. F. H. Hill, Supt.

N. Y., Newark—The Board of Managers, State Custodial Asylum, plans to build additions and alterations to its heating plant; new equipment will be installed. Estimated cost, $35,000.

N. Y., Niagara Falls—The Board of Directors of the Niagara Falls Gas and Electric Co., 306 Niagara St., will soon receive bids for a gas plant to be erected on the Riverway. Gas making machinery including gas holders, etc., will be installed. Estimated cost, $500,000. W. L. Adams, 311 Falls St., Engr.

N. Y., Ogdensburg—The New Jersey Zinc Co. plans to rebuild its power house which was recently destroyed by fire. Loss about $300,000.

N. Y., Thiells—The Board of Managers, Letchworth Village, plans to build an additional central heating plant and install equipment. Estimated cost, $225,000.

N. Y., Utica—The Board of Managers, Utica State Hospital Comm., Albany, plans to install new boilers and make all necessary changes in the central heating plant at Utica State Hospital. Estimated cost, $130,000.

N. J., Cape May—The Vulcan Heat, Light and Power Co. plans to improve the equipment in its plant. H. H. Ross, Supt.

N. J., Newark—The Board of Freeholders, Essex Co., will receive bids until May 1 for alterations and additions to the heating, piping and mechanical equipment in the power house and throughout the various buildings of the Essex County Hospital, Overbrook. Runyon & Carey, 845 Broad St., Newark, Consult Engr. Noted June 28.

Penn., Bristol—The Town Council plans to change the motive power of the pumping station from steam to electricity.

Penn., Harwood Mines—The Philadelphia Electric Co., 10th and Chestnut Sts., Philadelphia, and the Electric Bond and Share Co., 71 Bway., New York City, plans to extend their electric power stations here and build 3 new ones.

Penn., Mauch Chunk—The Town Council has plans under consideration for improvements to its electric street lighting system.

Penn., Philadelphia—The Bureau of Yards and Docks, Navy Dept., Wash., will soon award the contract for the installation of 3 electrically operated traveling cranes for its air craft factory. Estimated cost, $56,000.

Penn., Reading—The Reading Ry. plans to build a power house on Tulip and Somerset Sts. S. T. Wagner, Reading Terminal, Philadelphia, Ch. Engr.

Ala., Headland—City voted $10,000 bonds to improve its electric lighting and waterworks systems.

Ala., Mobile—The Moran Shipbuilding Co. plans to enlarge its electric lighting plant and shipyards.

Ky., Mount Olivet—The Mount Olivet Electric Light and Power Co. plans to install either a storage battery or a small engine and a 10 kw., 220 volt, d. c. generator. J. H. Kain, Owner.

Ohio, Massillon—Massillon Electric and Gas Co. plans to rebuild its electric lighting plant which was recently damaged by fire. Loss about $250,000. F. L. O'Connor, Supt.

Ill., Chicago—The Illinois Central plans to build a $60,000 power house at its Burnside plant, 95th and Cottage Grove Ave. A. S. Baldwin, 35 East 11th Place, Ch. Engr.

Ill., Springfield—The St. Johns Hospital plans to install wiring and a heating system. Estimated cost, $3000 and $10,000 respectively. Helme & Helme, Springfield, Arch.

Ill., Springfield—The Springfield Light, Heat and Power Co. has applied to the State Utility Commission for permission to issue $100,000 in bonds; the proceeds will be used to extend its mains and purchase boilers and mechancial equipment. J. E. Dalby, 1157 North 3rd St., Supt.

Wis., Butternut—The Butternut Electric Light and Power Co. plans to install an additional 3 wire generator with 15 kw. capaciy. W. J. Schultz, Mgr.

Wis., Milwaukee—The C. Ansted Leather Co., 560 Commerce St., plans to install an additional 150 kw. steam generating unit and 16 electric motors of an aggregate of 165 hp. Estimated cost $10,000.

Minn., Tommald—City has plans under consideration for the installation of an electric lighting system.

Kan., Peru—City plans to install an electric lighting plant here.

Kan., Winchester—The Automatic Electric Light Co. of Kansas City plans to install an electric lighting and power plant near here.

S. D., Bradley—The Dakota Northern Power Co. plans to build a steam plant and install a 300 kw. reciprocating unit. E. H. Lewis, Secy.

N. D. Fargo—City plans to install an electric lighting plant at the water works station. J. J. Jordan, City Engr.

Mo., Kansas City—The Kenwanee Boiler Co., 1420 McGee St., is in the market for a hand power or electrically driven traveling crane on tracks, similar to locomotive type, with 20,000 lb. capacity.

Tex., Calvert—The Calvert Water, Ice and Electric Co. plans to extend its electric power transmission line from here to Bremond. A. E. Stoltz, Mgr.

Tex., Clyde—R. Cook plans to build an electric lighting and power plant here.

Tex., Dallas—Smith & Whitney, 1405 Southwestern Life Bldg., is in the market for a 300 kw., 250 volt. WX 2 or 3 wire direct current generating set, cross compound, non condensing, non releasing Corliss type engine; an engine type generator without engine but for direct connection to engine of above type would be considered.

Tex., Nixon—The Nixon Electric Light and Power Co., recently incorporated with $12,000 capital stock, plans to build an electric light and power plant. J. F. Wood, interested.

Ala., Birmingham—The Tennessee Coal, Iron and R.R. Co. plans to improve its power station at the Ensley blast furnaces. Equipment including a 7500 kw. turbo generator. J. H. Kain, Owner.

Va., Williamsburg—The Williamsburg Power Co. has increased its capital stock from $25,000 to $150,000; the proceeds will be used to build additions and make improvements to its plant.

Tex., Pleasanton—The City Council has taken over the plant of the Pleasant Ice and Electric Co. and plans to install additional equipment and machinery. F. H. Burmeister, Mgr.

Tex., Round Rock—S. E. Bergstron, Kerns, plans to build an electric lighting and power plant here.

Okla., Cyril—City plans to build an electric lighting plant.

N. M., Clovis—City voted $25,000 bonds for electrical improvements.

Wash., Chehalis—O. E. Anderson and associates plan to build a power plant here.

Wash., Mondovi—The Washington Water Power Co. plans to install electric lights here.

Wash., Snohomish—The Snohomish Dairy Products Co. plans to install an electric motor in several departments.

Que., Montreal—Lamontague, Ind., 338 Notre Dame St., W., plans to build a power house. Estimated cost, $10,000. E. Laurie & Co., 243 Bleury St., Engr.

Ont., Cobalt—The Mining Corporation of Canada, Ltd., plans to install electric driven pumps on scows and will purchase motors, pumps, pipe, etc.

Sask., Arcola—The Arcola Light and Power Co. plans to change its system from single phase 110 volts, to 3 phase 2300 volts. G. F. Robert, Mgr.

Ont., Haileybury—The Dickson Creek Mining Co. plans to install electrically driven drills at its property on Dickson Creek.

CONTRACTS AWARDED

N. H., Goffstown—The Manchester Traction, Light and Power Co. is building a new power house and a dam in the Greggs Falls district here. E. Farrell, Engr.

Mass., Boston—The Bureau of Yards & Docks, Navy Dept., Wash., has awarded the contract for the erection of a new power plant at the Navy Yard, here. Estimated cost, $35,000.

N. J., Trenton—The Crescent Insulated Wire and Cable Co., Olden and Taylor Sts., has awarded the contract for a 3 story, 83 x 103 ft. factory, to the Barclay White Co., 1713 Sansom St. Estimated cost, $100,000. The company will install an entire steam heating system, electric elevator and electric lighting system.

Penn., Philadelphia—The G. W. Smith Co., 49th and Botanic Ave., has awarded the contract for the erection of an addition to its boiler house, to J. N. Gill and Co., Otis Bldg. Estimated cost, $35,000.

Penn., Philadelphia—The L. Walther Manufacturing Co., Torresdale Ave. and N St., has awarded the contract for the erection of an addition to its boiler plant, to G. H. Thirsk, 1919 West Berks St. Estimated cost, $21,000.

Ky., Nortonville—The Norton Coal Mining Co. has awarded the contract for the erection of an addition to its central power plant, to the Ruby Lumber Co., Madisonville.

Neb., Lincoln—The State Board of Control has awarded the contract for a power house to be erected at the penitentiary, to R. C. Stake. Estimated cost, $13,380.

Okla., Park Hill—C. Sells, Commissioner of Indian Affairs, Wash., D. C., has awarded the contract for the installation of a steam heating plant in the Cherokee Training School, to the Bradley Heating Co., St. Louis, Mo.

Ore., Helix—The Helix Mill Co. has awarded the contract for wiring for the installation of electric light power plant in the mill, to J. Vaughn, 206 East Cort St., Pendleton.

Calif., Fresno—The San Joaquin Light and Power Co. is building a new substation east of the Standard reservoir farm. New equipment including four 1000 kva. transformers, switches, etc., will be installed. A. G. Wishon, Gen. Mgr.

THE COAL MARKET

Boston—Current quotations per gross ton delivered alongside Boston points as compared with a year ago are as follows:

ANTHRACITE

	Circular Apr. 25, 1918	Individual Apr. 25, 1918
Buckwheat	$4.60	$7.10—7.35
Rice	4.10	6.65—6.90
Boiler	3.90	.....
Barley	3.60	6.15—6.40

BITUMINOUS

Bituminous not on market.

Pocohontas and New River, f.o.b. Hampton Roads, is $4, as compared with $2.85—2.00 a year ago.

*All-rail to Boston is $2.60. †Water coal.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* are as follows:

ANTHRACITE

	Circular Apr. 25, 1918	Individual Apr. 25, 1918
Pea	$4.90	$5.65
Buckwheat	4.45@5.15	4.80@5.50
Barley	3.40@3.65	3.80@4.50
Rice	3.90@4.10	3.00@4.00
Boiler	3.65@3.90	.....

Quotations at the upper ports are about 5c. higher.

BITUMINOUS

	F.o.b. N. Y. Gross	Mine Price Net	Gross
Central Pennsylvania	$5.06	$3.05	$3.41
Maryland—			
Mine-run	4.84	2.85	3.19
Prepared	5.06	5.05	3.41
Screenings	4.50	2.55	2.85

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The ratte to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Apr. 25, 1918	One Yr. Ago	Apr. 25, 1918	One Year Ago
Pea	$3.45	$2.80	$4.35	$3.70
Barley	2.15	1.50	2.40	1.75
Buckwheat	3.15	2.50	3.75	3.40
Rice	2.65	2.00	3.65	3.00
Boiler	2.45	1.80	3.55	2.90

Chicago—Steam coal prices f.o.b. mines:

Illinois Coals	Southern Illinois	Northern Illinois
Prepared sizes	$2.65—2.80	$3.35—3.50
Mine-run	2.40—2.55	3.10—3.25
Screenings	2.15—2.30	2.85—3.00

Smokeless Coals	So. Ill., Pocohontas, Pennsylvania and W. Va.	Hocking, East Kentucky and West Va. Splint
Prepared sizes	$2.60—2.85	$2.85—3.35
Mine-run	2.40—2.60	2.60—3.00
Screenings	2.10—2.55	2.35—2.75

St. Louis—Prices per net ton f.o.b. mines are as follows:

	Williamson and Franklin Counties April 25, 1918	Mt. Olive & Staunton April 25, 1918	Standard April 25, 1918
6-in. lump	$2.65-3.00	$2.65-2.80	$2.65-2.80
2-in. lump	2.65-3.00	2.65-2.80	2.25-2.50
Steam egg	2.65-2.80	2.35-2.50	2.25-2.40
Mine-run	2.45-2.60	2.45-2.60	2.45-2.60
No. 1 nut	2.65-3.00	2.65-2.80	2.65-2.80
2-in. screen	2.15-2.40	2.15-2.40	2.15-2.40
No. 5 washed	2.15-2.30	2.15-2.30	2.15-2.30

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Lump & Nut	Slack and Screenings
Big Seam	$1.90	$2.15	$1.65
Pratt, Jagger, Corona	2.15	2.40	1.90
Black Creek, Cahaba	2.40	2.65	2.15

Government figures.

Individual prices are the company circulars at which coal is sold to regular customers irrespective of market conditions. Circular prices are generally the same at the same periods of the year and are fixed according to a regular schedule.